Ser: 3 **Session:** 1 A Electronics and Power Systems Health Management

Presenting Author: Mark Walker

Organization: General Atomics

Country:

Paper Title: Power Systems Health Management for Unmanned Aircraft

Co Authors: Kim Wilkins

Abstract:

Over the past decade there has been a continuing increase in demand for Remotely Piloted Aircraft (RPA). Furthermore, the mission complexity and duration for these aircraft has also increased. As a result, mission planners are demanding that their assets operate without failure for extended periods of time. One of the most critical systems on board long duration flight unmanned aircraft is the electrical power distribution system. Such power systems provide power to critical components throughout the aircraft, and failures within the power system affect the performance of virtually all of its major functions. Advanced Prognostics and Health Management (PHM) systems are being developed that aid in both the detection and prediction of critical failures that can interfere with the operational availability of RPA. This paper describes the benefits of applying such systems to the health management of electrical power distribution systems on board unmanned aircraft.

Ser: 61 **Session:** 1 A Electronics and Power Systems Health Management

Presenting Author: Antonio Ginart

Organization: Impact Technologies, LLC

Country:

Paper Title: Fault Tolerance for Actuators with Extended Operation under Transistor Trigger Suppression and Winding Fault Isolation

Co Authors: Irfan Ali, Patrick W. Kalgren and Michael J. Roemer

Abstract:

Actuator power drives are often designed to cease operating in presence of faults and in critical applications, adding redundancy is the preferred strategy to providing extra operational reliability. Although added redundancy can be an effective fault tolerant technique, it faces many drawbacks from an extended reliability point of view. For instance, redundant systems are designed to operate independently in order to avoid propagating the fault; however, in many cases fault propagation still occurs due to the fact that both systems are exposed to similar operating events. For this reason, it is important to explore and optimize the possibilities of newly available online condition assessment technologies that support early fault detection and accommodation techniques in the individual systems themselves. This is the technology development that is presented herein, with extended operation of the system obtained with the use of a dormant program that is triggered through early detection and isolation of specific faults. The fault accommodation strategies are developed in order to optimize the operation of the system with a specific goal of continued operation.

Generally an actuator drive has three windings and six transistors; this paper explores the possibilities of operating the system when one or several of these components are faulty. In this case, fault-accommodation techniques are demonstrated in order to achieve starting and extended operation of a faulty actuator system. Two main types of fault accommodation are described; the first consists of starting an actuator with a transistor open. The second fault demonstration consists of starting an actuator with a main winding failure. The paper includes the theoretical development and the experimental results that validate these techniques.

Ser: 62 **Session:** 1 A Electronics and Power Systems Health Management

Presenting Author: Chetan Kulkarni

Organization: Vanderbilt University

Country:

Paper Title: Model-Based Avionics Systems Fault Simulation and Detection

Co Authors: Gautam Biswas, Kyusung Kim, Raj Bharadwaj

Abstract:

This paper proposes a combined energy-based model with an empirical physics of failure model for degradation analysis and prognosis of electrolytic capacitors in DC-DC power converters. Electrolytic capacitors and MOSFET's have higher failure rates than other components in DC-DC converter systems. For example, in avionics systems where the power supply drives a GPS unit, ripple currents can cause glitches in the GPS position and velocity output, and this may cause errors in the navigation solution causing the aircraft to fly off course. A model based approach to studying degradation phenomena enables us to combine the energy based modeling of the DC-DC converter with physics of failure models of capacitor degradation, and predict using stochastic simulation methods how system performance deteriorates with time. We have employed a topological energy based modeling scheme based on the bond graph (BG) modeling language for building parametric models of multi-domain physical systems. Our current work adopts a physics of failure model (Arrhenius Law) for equivalent series resistance (ESR) increase in electrolytic capacitors subjected to electrical and thermal stresses. The derived degradation model of the capacitor is reintroduced into the DC-DC converter system model to study changes in the system performance using Monte Carlo simulation methods.

Ser: 19 **Session:** 1 A Electronics and Power Systems Health Management

Presenting Author: Sonia Vohnout

Organization: Ridgetop Group, Inc.

Country:

Paper Title: A Prognostics Approach for Electronic Damage Propagation and Analysis in Electromechanical Actuator Systems

Co Authors: Neil Kunst, Chris Lynn, Byoung Uk Kim

Abstract:

As the aviation industry evolves toward next-generation fly-by-wire vehicles, hydraulic and electrohydrostatic actuators (EHA) are replaced with their electro-mechanical counterparts. By eliminating fluid leakage problems while reducing weight and enhancing vehicle control, the feasibility of electromechanical actuators (EMA) in avionic applications has been established. However, due to the inherent nature of electronic components and systems to fail, improved diagnostic and prognostic methods are sought to keep the all-electric aircraft safe. An innovative approach to the emulation of avionic EMA operation is presented. Realistic load profiles can be applied to a scaled-down EMA testbed while executing the in-flight actuator motion commands in real-time. The proposed EMA Emulator is designed to enable the insertion of degraded electronic components, such as the power transistors of the motor drive, to analyze the servo loop response of an aged actuator system. That is, the EMA motion trajectory, or position, data is acquired with various levels of power electronics degradation to populate a fault-to-failure progression (FFP) database of actuator servo loop response signatures. Ultimately, the FFP signature database is leveraged to develop prognostic methods to assess the State of Health (SoH), estimate Remaining Useful Life (RUL), and support Condition-Based Maintenance (CBM) of avionic EMA systems.

Ser: 21 **Session:** 1 A **Electronics and Power Systems Health Management**

Presenting Author: Sonia Vohnout

Organization: Ridgetop Group, Inc.

Country:

Paper Title: Innovative IEEE 1451 Power System Prognostic Sensor

Co Authors: Neil Kunst, Chris Lynn, Byoung Uk Kim and Fernando Figueroa

Abstract:

As the Stennis Space Center (SSC) leads the push toward realization of integrated systems health management (ISHM) for new NASA exploration missions, the IEEE 1451 standard has emerged as the predominant interface for networking the smart sensors that monitor the health of complex aerospace systems-of- systems (SoS). Ridgetop Group joins the SSC effort by leveraging its state-of- the-art electronic power systems prognostics developed for the Ames Research Center (ARC) under NASA's companion integrated vehicle health management (IVHM) directorate. Non-intrusive monitoring of power systems' state of health (SoH) can be facilitated by examining the power system response to an impulse load change, and extracting the characteristic frequencies of this response. The proposed IEEE 1451 smart power sensor technology, which can be implemented or packaged as a single-board system or system on chip (SoC), is based on the extraction of the eigenvalues that comprise the damped sinusoidal "ringing" response of electronic power systems, including switch mode power supplies (SMPS) and electromechanical actuator (EMA) servo drive power stages. By default, the smart sensor's analog transducer output indicates the SoH or remaining useful life (RUL) of the entire power system, taking into account the health of all of the individual system components (e.g. SMPS output filter capacitor, feedback amplifier, PWM controller, etc). The analog output signal is set to a maximum value when the sensor detects that the power system is 100% healthy and a minimal value when the system has completely failed, or 0% healthy. Typically, the default measurement mode is all the end-user (e.g., aircraft pilot) cares about. That is, does the critical system being monitored have enough "fuel" to complete the mission? On ground, however, the maintenance crew and original equipment manufacturer (OEM) may be interested in recording degradation statistics on the individual system components. A key, novel element of the proposed innovation is the ability of the smart power sensor to be reconfigured programmatically by the user. Individual system components can be monitored to determine the primary contributors to system wear-out and improve next-generation OEM designs.

Ser: 42 **Session:** 1 B Signal Analysis

Presenting Author: Matt Rigdon

Organization: Penn State University Applied Research Laboratory

Country:

Paper Title: Application of Statistical Based Data Mining Techniques to Operational Data for Ground Vehicle Diagnostics

Co Authors: Jeffrey Banks, Karl Reichard, Bryon Rattman, Ling Rothrock

Abstract:

More and more systems, both military and commercial, have the capability to record and archive operational and performance data. Many of these systems record and archive data from existing sensors and signals used to control platform operation or provide feedback to the operators. The challenge is to make the best use of these available signals to provide information on system health and capability, even though most of the signals and sensors were not originally selected based on their ability to provide information about system health. Furthermore, the recorded data is usually sampled at low sample rates and is often averaged or aggregated before archival. For a demonstration program, data was collected from several U.S. Army vehicles and this data was used for this analysis. The focus of the research described in this paper was to quantify the normal range for each sensor output as a function of engine mode. This paper describes the application of three data mining techniques to evaluate the operational range and detect anomalies in the sensor data, which was collected over a six month time period that the vehicles were operated. The first approach, Analysis Of Means (ANOM) focuses on characterizing normal variances in sensor signals within a single platform. Time series data from sensors are analyzed on a vehicle-by-vehicle basis to determine if any sensors within a particular vehicle are responding in an anomalous manner relative to the same or similar sensors across the group of vehicles. The second approach, Analysis Of Variances (ANOVA) compares variances in sensor signals across a group of vehicles to detect anomalous sensor behaviors. The third approach uses clustering techniques from pattern recognition to identify vehicles with similar behavior and can identify vehicles whose behavior is anomalous compared to the other clusters. Each data mining technique is described along with preliminary results from the resulting data analysis.

Ser: 58 **Session:** 1 B Signal Analysis

Presenting Author: Arun Menon

Organization: Data Physics Corporation

Country:

Paper Title: On the Use of the Hilbert Transform for Amplitude and Phase Demodulation Applications

Co Authors:

Abstract:

Vibration analysis of rotating machinery frequently involves the study of rolling element bearings and gear systems. While routine auto power spectrum analysis is widely applied in diagnostics of such mechanical components, the low energy levels associated with the incipient stages of faults in the same requires the use of more sophisticated techniques. Traditional envelope analysis techniques are very useful in exposing amplitude modulating frequencies, but the mechanism used does not retain information about the phase or frequency modulating components in a given signal. This paper discusses the use of the Hilbert Transform for amplitude and phase or frequency demodulation along with examples of its application. Also presented are concepts relating to the analytic signal, or envelope, and how the use of zoom and synchronous averaging analysis may be used to concentrate the analysis on events of interest.

Ser: 55 **Session:** 1 B Signal Analysis

Presenting Author: David Corelli

Organization: IMI Sensors

Country:

Paper Title: So You Think You are Making Accurate Measurements?

Co Authors:

Abstract:

It is important to be able recognize bad data and understand the limitations of good data. The paper shows how mounting and internal filtering found in most industrial sensors reduce saturation problems but adversely affect high frequency measurements such as HFE and demodulated spectra. It suggests ways to deal with the problems and how to run some simple tests to determine your sensor's system response. Additionally, typical sources of measurement errors are defined and many examples of actual data are included. Specific topics included are: sampling, sensitivity tolerance, leakage, saturation, ski slope, sensor mounting, digital signal processing, long cable distortion, and others.

Ser: 35 **Session:** 1 B Signal Analysis

Presenting Author: Len Gelman

Organization: Cranfield University

Country: UK

Paper Title: New Time-frequency Adaptive Techniques for Damage Diagnosis in Non-stationary Conditions

Co Authors:

Abstract:

The classical second order and higher order spectral techniques have been widely investigated for damage diagnosis for stationary conditions. However, for some important practical applications in rotating machinery (e.g. change of the shaft frequency and load during machinery operation etc.), it is necessary to process non-stationary signals. The classical techniques are not suitable for those signals. The purposes of this paper are to present: • new time-frequency adaptive second order and higher order spectral techniques developed by Cranfield for fatigue damage detection/diagnosis for non-stationary conditions. • validation of these techniques by simulation and experiments in laboratory and field conditions It is shown that the proposed techniques offer an essential improvement (up to 70%-150%) in effectiveness of damage diagnosis in comparison to the traditional techniques. This paper summarises Cranfield's 5 year successful experience in using the new techniques for damage diagnosis.

Ser: 40 **Session:** 1 B Signal Analysis

Presenting Author: David He

Organization: University of Illinois-Chicago

Country:

Paper Title: Hybrid Ceramic Bearing Prognostics using Particle Filtering

Co Authors: Ruoyu Li, Jinghua Ma, Arvind Panyala

Abstract:

Ceramic bearings are quickly replacing conventional steel ball bearings in various fields and applications because they exhibit a service life three times longer than that of steel bearings. In this paper, a methodology for hybrid ceramic bearing prognostics using particle filtering is presented. The methodology is validated using real hybrid ceramic bearing run to failure test data. The validation results have shown the effectiveness of the presented prognostics methodology.

Ser: 56 **Session:** 1 D CBM

Presenting Author: Dennis Moore

Organization: RJ LeeGroup Inc

Country:

Paper Title: Reliability Centered Maintenance: Determining Metrics That Drive the Bottom Line

Co Authors: Juan Gonzalez (SASAI)

Abstract:

The critical component to any successful program is the measurement of key value drivers that demonstrate the realization of returns on investment. The scorecard approach provides program managers with the useful feedback needed to determine if new policies and procedures are needed or if new technology is desired to help drive the program goals.

A reliability centered maintenance program is no different. Several key metrics can be used to determine the success or failure of new methods or technology integrations. The purpose of this paper is to describe several of these metrics, their correlation to the bottom line of the overall maintenance program. In addition, the paper will offer methods of tracking and scorecard monitoring of these metrics in support of long term program goals

Ser: 1 **Session:** 1 D CBM

Presenting Author: Rich Wurzbach

Organization: Maintenance Reliability Group, LLC

Country:

Paper Title: Streamlined Grease Analysis to Complement Vibration and Other Diagnostic Technologies

Co Authors:

Abstract:

Oil analysis is well established as a routine tool to optimize maintenance activities, improve reliability and equipment life and prevent component failures. As part of a comprehensive Predictive or Condition Based Maintenance program, lubricant analysis is an effective complement to other diagnostic technologies such as vibration analysis, infrared thermography, ultrasonic detection and motor circuit evaluation. However, when the equipment is grease lubricated rather than oil lubricated, the important lubricant analysis piece is usually left out of the mix. However, new tools have been developed for improved sampling techniques and grease analysis tests to allow the inclusion of lubricant analysis for grease lubricated equipment. This paper will discuss the challenges and options to obtain representative and consistent grease samples from motors, motor operated valves, and other critical equipment, and a new method for reliably and repeatably determining changes in consistency for samples of grease as small as 1 gram. Grease sampling and analysis programs have proven valuable in confirming equipment degradation trends seen with other technologies, as well as establishing root-causes for failure and damage, often where other technologies have been unable to address recurring failures, particularly related to inadequate lubrication.

Ser: 25 **Session:** 1 D CBM

Presenting Author: Jason Hines

Organization: PSU Applied Research Lab

Country:

Paper Title: Development of a Fuel System Advanced Diagnostic and Predictive Capability for the M2/M3 Bradley Fighting Vehicle

Co Authors: Scott Pflumm, Jeffrey Banks and Dan Rhodes

Abstract:

The US Army is leading the development of integrated system health management (ISHM) technology that provides the operator and maintainer with an improved diagnostic, predictive and sustainment capability for their platforms including the M2/M3 Bradley Fighting Vehicle. In order to ascertain where health monitoring technology would provide the greatest benefit in terms of decreasing diagnosis time, increasing maintenance effectiveness, decreasing No Evidence of Failure (NEOF) rates and facilitating the migration to a 2-tier maintenance system, a vehicle degrader analysis was conducted. The results of the degrader analysis indicated that the Bradley fuel system was one of the top candidates for the effective implementation of ISHM technology.

This paper will describe the design of a Bradley fuel system test bed for conducting seeded fault testing, the development of on-platform diagnostic and predictive capabilities for the fuel system that leverages existing sensors currently installed on the vehicle and the creation of a physics based model for facilitating the development/validation of fuel system health management technology. The focus will be to demonstrate a methodology for the development of common diagnostic and predictive technologies for ground combat vehicle fuel systems, which includes the selection of appropriate existing and potential additional sensors, algorithm development and training, and vehicle health management system technology integration recommendations.

Ser: 44 **Session:** 1 D CBM

Presenting Author: Matt Sedlak

Organization: RJ LeeGroup Inc

Country:

Paper Title: Mashups to Support CBM+ Software Application Transition from R&D to Product

Co Authors:

Abstract:

Software projects within DoD have long been plagued with high failure rates due to cost overruns, inadequate feature delivery or insufficient stakeholder support to name a few. An application Mashup tool is one method that can help reduce failure rates by “Fast Tracking” R&D into Product by shortening the software development life cycle through reuse of existing applications (services) to generate new applications (services). Mashups are currently supporting CBM+ application and integration of appropriate processes, technologies, and knowledge-based capabilities to improve the reliability and maintenance effectiveness of DoD systems and components. The CBM+ Mashup is built on Service Oriented Architecture (SOA) and Web Service exposure standards to generate new applications. One specific application for Mashup within CBM+ is an Engineering Mashup. The Engineering Mashup is a web application that provides aggregation, transformation, and computational services over top of the engineering data exposed by one or more sources to produce new reusable data sources. It supports the uploading and execution of 3rd party algorithms against large data sets while providing 3rd party intellectual property assurance. It focuses on run time development, drag-and-drop, and Subject Matter Expert empowerment. Overall, the Engineering Mashup provides a significant cost savings to DoD by allowing the generation of new applications in minutes versus Traditional Web Application development that can take months. Given RJ Lee Group’s background through United States Air Force contract initiatives, RJ Lee Group has the proven capability designing and implementing enterprise Mashup solutions within DoD meeting CBM+ requirements that support Weapon System Health Management.

Ser: 24 **Session:** 1 D CBM

Presenting Author: Chris Sautter

Organization: University of Alabama in Huntsville

Country:

Paper Title: The P-F Interval: The Cornerstone of Condition Based Maintenance

Co Authors:

Abstract:

This paper will examine the relationship between the P-F interval, a necessary core of Condition Based Maintenance CBM, and the move to system prognostics. As both the private sector and government programs focus on diagnostics and prognostics to achieve fundamental improvements in system availability and readiness while reducing overall costs, it is necessary to have a clear process to achieve these goals. A process roadmap developed by the Reliability Lab at the University of Alabama in Huntsville, Figure 1, will be used to illustrate how prognostics can be a desired result of a well documented analysis. The present process map has been used successfully on a number of weapon systems to examine difficulties experienced in the sustainment phase of the life cycle. It is also valid in the design phase when the addition of technologies that support prognostics can have the largest impact on Total Life Cycle Costs. Based on the principles founded in Reliability Centered Maintenance, RCM, this paper will use as its guide the work done by John Moubary and expanded by the Maintenance Steering Groups within the FAA. It is necessary to note that while prognostics are a clear goal of many current programs, it must be realized that the choice to move to a maintenance paradigm using prognostics must be both technically and economically feasible. Much of the anecdotal evidence in current military weapon systems finds a rush to widespread use of sensor technologies. While in many cases sensors are necessary to support prognostic capabilities, before adopting this focus, design and maintenance engineers need to understand that the ability to use prognostics is only one of the four paths of RCM. The others include Time Directed Maintenance, Run-to-Failure and no maintenance solution. All four of these categories must be considered in order to provide the most cost beneficial approach to maintenance. This process map has been used by DoD within their CBM working groups and it was also used to assist the Army G-4 in their document that defines CBM+ within the Army Maintenance programs.

Ser: 69 **Session:** 1 D CBM

Presenting Author: Romano Patrick

Organization: Impact Technologies, LLC

Country:

Paper Title: Transitional Failure Testing and Prognostics Software Development Applied to Helicopter Critical Component

Co Authors: Matthew Smith, Carl Byington, George Vachtsevanos, Daniel R. Wade, Daniel T. Suggs

Abstract:

This paper discusses a series of diagnostic and prognostic software modules to enhance safe time between overhaul of a helicopter drive train component and an overall shift towards Condition-based Maintenance for U.S. Army air vehicles. Fleet data and seeded fault tests are used to validate and demonstrate the ability of the software suite to detect component faults early and predict the rate of damage progression. The paper also reports on efforts aimed at establishing a framework for properly dealing with fault modes and data variability, improving the characterization of the failure mechanisms, selecting and adjusting algorithms for performing data processing, diagnostics and prognostics to increase analysis performance, and ultimately determining safe times for performing maintenance (planning and servicing) by incorporating multiple sources of evidence.

The demonstration platform of these developments is a drive train bearing used by helicopters in use by the U.S. Army. These developments support the goal of the U.S. Army Condition Based Maintenance program (CBM+) to transition to condition-based maintenance of vehicle components from the current use of time-based decisions using “time before overhaul” (TBO) definitions, and have the potential to be appended into a ground station monitoring environment or at a remote analysis location in support of maintenance planning and logistics

Ser: 22 **Session:** 2 A Health Management Tools and Capabilities

Presenting Author: Allison Toms

Organization: GasTOPS Inc.

Country:

Paper Title: Detecting Bearing and Gear Failures through At-Line Wear Debris Analysis

Co Authors:

Abstract:

To improve safety of flight operations, increase equipment availability and decrease ownership costs, it is imperative to monitor the condition of bearings and gears. To achieve full benefits, the utilization of technologies that can provide an early indication of potential failure is necessary, thus providing time for remediation and reduction of secondary damage. Traditionally, wear debris damage is detected through periodic sampled oil analysis that generates elemental indication of bearing or gear damage. A viable and available alternative to sampled oil analysis is provided with an at-line wear metal alloy detector. The metallic particles captured by a filter or chip collector or oil sample can be analyzed at-line utilizing x-ray technology and thus eliminate the need for laboratory wear-metals analysis. Results achieved from individual particle analysis provide a comprehensive analysis because the size of the particle and actual metal alloy can be identified. This technology, investigated by AFRL, has successfully been transitioned to a commercial product. The Air Force initiated a project to provide a compact, automated, modular particle alloy identifier for at-line use. The developed product provides a comprehensive first-line capability in a single, transportable instrument that provides metallurgical analysis; pinpoints damaged internal components and can be used to determine system serviceability.

Ser: 60 **Session:** 2 A Health Management Tools and Capabilities

Presenting Author: Carl Byington

Organization: Impact Technologies LLC

Country:

Paper Title: Real-time Oil Quality and Metallic Debris Monitor for Gearbox Applications

Co Authors: Nicholos Mackos, Impact Technologies Carl Palmer PhD, Impact Technologies Cody Ture, Impact Technologies; Garrett Argenna; Rachel Moss, GasTOPS Inc Allison Toms, GasTOPS Inc Kevin Goddard, GasTOPS Ltd John Moffatt, US Army RDECOM/AATD

Abstract:

Gearbox health is paramount to ensuring high machinery reliability and maximum uptime. Offline oil analysis, which has traditionally been implemented to this end, can provide valuable insight into the health and operation of a gearbox as well as a verification that the lubricant itself is within specification and still able to prevent wear. Metallic debris monitoring is the gold standard for fatigue spall detection and is a well accepted method for preventing failure due to wear. Metallic debris identification also provides valuable insight with respect to root cause analysis, as wear can often be isolated to components of matching elemental composition. The economic and logistics challenges associated with offline oil analysis make an online sensing technology for gearbox oil quality and debris highly desirable. To this end Impact Technologies LLC and GasTOPS Inc collaborated on a US Army RDECOM / AATD program to explore and test the viability of a combined online oil quality and metallic debris monitoring system with initial application to rotorcraft gearboxes. Impact's lubrication system test stand, designed to replicate the pressure, flow and temperature characteristics of modern lubrication systems was used for sensing technology evaluation in the first phase of this program. A Pareto analysis identified water contamination and incorrect fluid addition as the primary failure modes of interest with respect to oil quality; the oil quality sensing mechanism tested successfully demonstrated the capability to discriminate and quantify these failure modes. The test stand was also modified to allow for the controlled addition of metallic particles; the selected oil debris monitoring technology successfully counted all types of test particles used. A particle capture device was also implemented to facilitate demonstration of at-line x-ray fluorescence methods of wear particle identification. The following paper outlines the results of these tests and draws conclusions.

Ser: 79 **Session:** 2 A Health Management Tools and Capabilities

Presenting Author: Jack Poley

Organization: Kittiwake Americas, Inc

Country:

Paper Title: "Site-Direct" Oil Analysis completes the Condition Monitoring goal of Continuous Machine Monitoring

Co Authors:

Abstract:

The advent of oil circuit sensors beyond pressure and temperature has elevated Oil Analysis into a real time event, allowing this invaluable process to take its place alongside Vibration Analysis, long a real time tool for machinery condition monitoring.

Oil condition and particle-monitoring sensors were heretofore not viable because they weren't technically effective, nor were they dependable in rugged conditions.

Earlier attempts to manufacture sensors for oil condition assessment met with repeated failure, as technology had not been fully developed. In the early 21st century we are now seeing products coming forth that finally meet the promise of a holistic CM program, where "CM" can also stand for "Continuous Monitoring", opening significant pathways to greater value from Condition Monitoring programs than ever before.

Ser: 4 **Session:** 2 A Health Management Tools and Capabilities

Presenting Author: Mark Walker

Organization: General Atomics

Country:

Paper Title: A Model-based Reasoning Framework for Prognostics and Health Management

Co Authors: Ravi Kapadia

Abstract:

Model-based reasoning systems offer unique capabilities relative to determining the health and real-time operational availability of mission critical systems and equipment. In particular, the ability to model and reason over the processes and across the subsystems of a system aids in improving operational efficiency, providing situational awareness, enforcing policy and procedure, and delivering the objectives of Reliability Centered Maintenance (RCM) and Condition Based Maintenance (CBM). This paper presents such a system – known as the Health, Monitoring, Assessment, and Prognostics (HealthMAP) engine – and discusses the strengths of the system relative to its ability to deliver the objectives of Prognostics Health Management (PHM), as well as facilitating the implementation and future modification of system behavior. The engine is currently being used to deliver similar capabilities for unmanned aircraft, next generation U.S. Navy shipboard systems, as well as for mission critical systems operated by the National Aeronautics and Space Administration (NASA).

Ser: 50 **Session:** 2 A **Health Management Tools and Capabilities**

Presenting Author: Mike Schoeller

Organization: Impact Technologies LLC

Country:

Paper Title: Bringing the Benefits of Integrated Vehicle Health Management to Unmanned Systems

Co Authors: Theodore Meyer; Mr. Jason Fetty and Mr. Treven Baker (AATD, US Army)

Abstract:

The work presented summarizes developments under an on-going effort to bring state-of-the-art vehicle health management technologies to operations, maintenance, and logistics personnel working to keep unmanned assets operational. The goals of an Integrated Vehicle Health Management (IVHM) system include helping to improve safety and control ownership costs of its host platform. Impact Technologies, LLC has developed a prototype IVHM system suitable for manned and unmanned aerial, ground, and sea vehicles. In addition to usage monitoring, the 3lb. Unmanned Systems-Integrated Vehicle Health Management (US-IVHM) system provides near real-time health state assessments of systems including drive train, power distribution, structural hot spots, and actuation subsystems, mission critical systems common to many types of manned and unmanned platforms. Health assessments provided by the IVHM system enable the evaluation of the vehicle's mission demands against its functional capabilities, both current and projected, enabling maintenance and repair recommendations and valuable lead-time to maintainers and the logistics chain. Content will focus mainly on the vehicle-wide approach used to extract and assess health knowledge from these key systems and subsystems, providing this knowledge to users in a meaningful manner which can aid in meeting DoD CBM+ (Condition Based Maintenance–Plus) and PBL (Performance-based Logistics) initiatives.

Ser: 70 **Session:** 2 A Health Management Tools and Capabilities

Presenting Author: Bill Marscher

Organization: Mechanical Solutions Inc

Country:

Paper Title: Active Electrical and Mechanical Techniques for Modal Analysis of Operating Equipment

Co Authors: William J. Kelly, Jeremy A. Weiss

Abstract:

Many PdM algorithms rely on sensors which monitor the response of systems strictly due to operational excitations. This so-called passive response provides useful narrowband spectral information that can be used to assess changes in excitation levels, such as imbalance or misalignment conditions. Passive response monitoring does not however provide high-fidelity information on the broadband spectra, therefore is difficult to use for assessing shifts in natural frequencies which may reflect structural deterioration. Active techniques, whereby the system is artificially excited, can provide such information. Monitoring the system ring-down from artificial mechanical or electrical impulse excitations can provide natural frequency, damping and mode shape information for subsequent structural health assessments. Furthermore, use of time averaging signal processing methods allows natural frequency information to be extracted while the machinery is operating or stationary. Mechanical stimulus can be in the form of automatic or manual instrumented hammer impact. Electrical stimulus can be in the form of an induced current perturbation to an electric motor phase, with the potential for evaluating shaft torsional natural frequencies.

Ser: 37 **Session:** 2 B Diagnostics

Presenting Author: Ken Singleton

Organization: KSC Consulting LLC

Country:

Paper Title: Case Study: New Pump Installation Analysis of Excessive Vibration

Co Authors: Bob McGinnis P.E., M.M. Engineering

Abstract:

The installation of centrifugal pumps is usually a straightforward process when best industry practices are followed. However, when best practices are not followed, poor performance, excessive maintenance, and unexpected downtime may result. This presentation shares the analysis and solution to problems which were created when the end user was left with three pumps with unacceptable levels of vibration at normal run speed and load. Six new pumps were installed in a waste disposal system and three of the motor-pump sets exhibited very high amplitude vibration beginning at initial start-up. Each of the three pumps exhibiting high vibration, were direct driven by 500 Hp AC motors with Variable Frequency Drives. They were supported on fabricated skids which were designed and fabricated by the local pump distributor rather than by the pump manufacturer. The skids were epoxy grouted to a concrete mass which was supported by several wood pilings driven to bedrock. Initial identification of a problem was by routine vibration data. Vibration exceeded 1.5 in/sec pk on one motor. Vibration of the other two units was lower, but not acceptable by the end user. The approach to solving this problem is described in the presentation and included the use of continuous multi-channel vibration data acquisition, operating deflection shape analysis (ODS) and impact modal analysis. The analysis identified natural frequencies of the fabricated skid and the motor pedestal within the operating speed range of the pump and motor, an inadequate number of anchor bolts, undersized concrete mass, and deformation of anchor bolt washers which were too thin. Recommendations were made to modify the skid by stiffening, installing additional anchor bolts, and increasing the size of motor hold down bolt washers. Changes were made by the end user as recommended, and vibration levels on all three units were reduced to well within acceptable levels.

Ser: 14 **Session:** 2 B Diagnostics

Presenting Author: Suri Ganeriwala

Organization: Spectra Quest Inc

Country:

Paper Title: Induction Motor Power Quality in Rotating Machines under Faults

Co Authors: Sankar Rengarajan, Suri Ganeriwala

Abstract:

This experimental study investigates the effect of mechanical and motor electrical faults in rotating machinery on motor power quality. Machinery Fault Simulator (MFS-Magnum) with a 3-phase, 0.5 HP induction motor was used for experiments. Mechanical and electrical faults such as shorted turn, broken rotor bars, mechanical imbalance, rolling element bearing faults, and rotor eccentricity were introduced. For each case, 16 channels of signal including shaft speed, vibration, motor voltages and currents were monitored and studied in time- and frequency-domains. Results indicate significant components in motor current spectrum due to shorted turn and rotor eccentricity faults. However, the effect of mechanical imbalance, shaft bearing faults and static eccentricity on current spectrum is not significant.

Ser: 41 **Session:** 2 B Diagnostics

Presenting Author: David He

Organization: University of Illinois-Chicago

Country:

Paper Title: Crack Fault Diagnosis in Drive Shafts Using Inverse Method

Co Authors: Venugopal Jayaraman

Abstract:

Cracks in drive shaft components have been one of the major reasons for mechanical failure of rotating systems for many years. In this paper, drive shaft crack size detection is modeled as an inverse problem. The inverse problem is described as the problem of determining the crack size given the shaft order values (both simulated and experimental) of the cracked shaft. The method proposed in this paper is to use a dynamic simulation model of a drive shaft to generate vibration responses due to various crack sizes. Vibration features such as shaft orders extracted from these vibration responses are used to build up a look up table for solving the inverse problem. A rotor balance simulator is used in the experiment to generate vibration features given the real crack sizes. The objective function for solving the inverse problem is defined to minimize the difference between the simulation and experimental results. A Newton-Raphson method is used to solve the inverse problem iteratively. The method has been validated with real drive shaft test data.

Ser: 77 **Session:** 2 B Diagnostics

Presenting Author: David Corelli

Organization: IMI Sensors

Country:

Paper Title: Extended Range RF Technology for Wireless Industrial Vibration Sensors

Co Authors:

Abstract:

The development of a practical wireless industrial vibration sensor poses a unique set of problems, including the necessity for long transmissions distances, low power consumption, and compatibility with existing monitoring systems, all of which are difficult problems to overcome. Extended Range RF (ERRF) Technology uses an ultra-narrow bandwidth radio frequency and has a low noise floor that results in -145 dBm sensitivity. This allows very long distance, point to point transmissions of overall vibration data in large industrial plants while using minimal amounts of power. Actual transmission distances in plants to date have been achieved up to ½ mile in and through buildings and up to 14 miles outdoors.

Ser: 76 **Session:** 2 B Diagnostics

Presenting Author: Nilimb Misal

Organization: Engineering Consultants Group, Inc

Country:

Paper Title: Adapting Advanced Pattern Recognition Software to Predict and Optimize Pulverizer Performance

Co Authors: Michael Santucci, Chance Kleineke

Abstract:

Pulverizers are used in coal-fired power plants for grinding coal to an appropriate fineness before the coal enters the boiler. Pulverizer maintenance is therefore vital in efficient operation of power plants. In recent years, advanced pattern recognition is increasingly being used for a wide variety of applications. In this study a highly specialized pattern recognition algorithm is used to monitor different parameters of pulverizer performance. The technique is designed for early detection of any process behavior different from normal. This paper discusses the basic workings of this method and its adaptations to pulverizer performance monitoring. Three actual cases are illustrated to demonstrate the advantages of using this method over traditional approaches.

Ser: 10 **Session:** 2 C **Failure Analysis**

Presenting Author: Edgar Gunter

Organization: RODYN Vibration Analysis, Inc.

Country:

Paper Title: Improving the Reliability of Large Diesel Engine Turbochargers

Co Authors: Dr Wen Jeng Chen, Eigen Technology

Abstract:

This paper deals with the analysis of a class of turbocharger used on locomotives and marine diesel engines. These larger sized turbochargers operate at 30,000 rpm and use floating ring bearings. The floating ring bearing is very common for use in the smaller high speed automotive engines. The use of floating ring bearings for the heavier turbochargers can encounter a number of difficulties which can lead to catastropic failure of the impeller and shaft depending upon operating conditions and clearance values of the bearings. This class of turbocharger mounted in floating ring bearings is inherently unstable with limit cyle whirling. The whirl orbits are controlled by the nonlinear bearing forces generated in the inner and outer fluid films of the bearing. Depending upon the bearing clearance values of the bearings, a sufficiently high whirl motion can occur causing the compressor impeller to rub leading to impeller and shaft failure. Dynamic models are presented to show the nonlinear behavior of the turbocharger and the magnitudes of the limit cycle motion. With many of the marine engines which lack turbocharger speed controls, it is shown under what conditions of overspeed the third bending critical speed may be achieved. Operation at these elevated speeds may lead to compressor failure due to rubbing of the inducer. Suggestions for reliability improvement are presented including use of a synthetic lubricant, additional oil filtration and proper bearing clearance values. Finally, an improved bearing design is presented using a multilobed bearing which removes the stability problem and elevates the third critical speed from the operating speed range.

Ser: 49 **Session:** 2 C **Failure Analysis**

Presenting Author: Debbie Aliya

Organization: Aliya Analytical

Country:

Paper Title: Materials Testing and Specimen Selection for Failure Analysis Support

Co Authors:

Abstract:

When a product or structure fails, the range of responses may be anywhere from none to an immediate widespread multi-departmental attack on the problem. An efficient and appropriate level of analysis must be tailored to answer well-defined questions that will enable identification of specific potential factors directly related to the actual apparent damage characteristics. For example, if there is a corrosion problem, the bulk composition or coating characteristics might be of interest. If there is a fracture problem, the yield or tensile strengths, or small details relating to the size or shape might be of greater interest. Data interpretation in failure analysis usually requires attention to shades of grey, rather than black and white “pass / fail” type judgments.

Ser: 17 **Session:** 2 C **Failure Analysis**

Presenting Author: Richard Holmes

Organization: VEXTEC Corporation

Country:

Paper Title: Predicting Fatigue Failure Using Intrinsic Material Properties

Co Authors: Raja Pulikollu

Abstract:

VEXTEC's proven fatigue prediction capability predicts the fatigue life of components based on the material properties of the alloy rather than using large empirical datasets. Current industry standards determine fatigue life based on time consuming and expensive physical component testing. VEXTEC's component fatigue model is unique because it uses intrinsic material properties and requires very limited testing to accurately predict fatigue durability. Our fatigue model simulates the microstructure of the material using probabilistic material properties such as grain size, grain boundary stress intensity factor, Poisson's ratio, defect size and defect density. The simulation predicts the number of cycles to complete each stage of crack growth and eventually component failure: crack nucleation, short crack growth and long crack growth. In a validation case, the fatigue model was created for a common aircraft alloy, aluminum 7075-T651 alloy using material properties and 5 smooth bar fatigue test points at a single stress level. This same fatigue model accurately predicted the fatigue life for a flat plate in bending for ten stress levels. VEXTEC's model can predict crack nucleation and propagation by modeling the microstructure from intrinsic material properties. Since this algorithm models the fatigue crack growth at the microstructure level, there are many advantages. Complex and variable missions can be modeled explicitly as cycle-by-cycle stress can be applied to the microstructure. Geometry becomes an extrinsic input to the model; therefore, fatigue life can be predicted for any geometric configuration. Initial flaws and defects as small as a grain can be explicitly modeled on the grain structure. VEXTEC simulations are presently used in numerous applications, providing benefit from the initial design phase all the way through to the maintenance depot. Using these simulations, the aircraft designer can assess the fatigue durability for new alloys without requiring a multi-million dollar test programs. The reliability of the aircraft parts can be accurately assessed prior to the first part manufacturing as well as in determining the durability and structural integrity of a repaired component.. The component geometry for new or repaired parts is explicitly modeled allowing the designer to reduce testing on new aircraft designs or repairs. Difficult and challenging field failures can be modeled and solved without extensive testing. Reduction in testing activities eliminates significant cost and time in aircraft design programs and reduces the downtime and related expense of unnecessary maintenance.

Ser: 11 **Session:** 2 C **Failure Analysis**

Presenting Author: Marco Caflisch

Organization: Failure Analysis Associates

Country:

Paper Title: Root Cause Analysis of Turbine Generator Vibration from Mechanical, Thermal, and Electrical Faults

Co Authors: Alexi Rakow, Joseph Rakow

Abstract:

This paper presents a series of root cause analyses of turbine generators exhibiting extreme vibratory behavior resulting from electrical, thermal, or mechanical faults. Examples of faults include rotor long (differential thermal expansion), rotor run-out, and stator electrical shorts. Within the framework of a few case studies, diagnostic methods and failure analysis techniques are presented. A newly developed non-contact instrument for measuring turbine rotor clearances, which enables in-situ turbine rotor condition monitoring, is discussed. The conglomeration of these investigations and diagnostic tools renders an overview of current industrial failure analysis efforts for rotating machinery.

Ser: 8 **Session:** 2 C Failure Analysis

Presenting Author: Marc Pepi

Organization: US Army Research Laboratory

Country:

Paper Title: Assessment of Aircraft Stairway Welds

Co Authors: James Catalano (RDRL-WMM-D)

Abstract:

The Materials Analysis Branch of ARL-WMRD was asked to provide technical support to the US Army CID during a cursory investigation of suspect welds located on aircraft stairways located at Ft. Campbell, KY. A total of three stairways were inspected; one purchased by Ft. Campbell on a Defense Logistics Agency (DLA) contract, and two others (of slightly different design) purchased from the contractor directly. Worldwide, stairs manufactured by this contractor had been mothballed due to an accident in Hawaii where a welded panel gave way, and a toddler fell 16-feet to the tarmac. The Air Force has inspected many of their assets, and found suspect welds. The CID requested the assistance of ARL to inspect these three Army assets, and to provide an overall assessment of these weldments based on the results of the examination.

Ser: 43 **Session:** 2 C **Failure Analysis**

Presenting Author: Chris Stecki

Organization: PHM Technology Pty Ltd

Country: Australia

Paper Title: Design for Testability: Anticipating Sensor Requirements through Advanced Failure Analysis

Co Authors: Shoshanna Rudov-Clark, Jacek Stecki, Adrian Ryan,

Abstract:

Using a qualitative dynamic simulation approach, advanced Failure Modes and Effects Analysis can anticipate system failure modes and associated monitoring requirements. This approach has been adopted in the development of a software tool (MADe) to support the Prognostics and Health Management (PHM) of the Joint Strike Fighter. Using model-based simulations of failure propagation through the various subsystems of the aircraft, a system-wide 'failure modes and effects database' is generated. For each potential failure mode, a signature of system-wide effects, known as a 'syndrome' can be identified and used to determine the inherent testability of the system and to automate the design and optimisation of sensor sets to fulfil FDI requirements. The same analysis approach is also used to verify the failure coverage (sometimes referred to as 'testability') of existing or legacy sensor sets. This paper provides a case study to demonstrate the principles behind this analysis approach and the potential for application to conceptual design or design upgrades of systems.

Ser: 64 **Session:** 3 B Material Health Management

Presenting Author: Mike Platt

Organization: Mechanical Solutions, Inc.

Country:

Paper Title: Advances in Non-Contacting Stress Measurement for Turbomachinery Blades

Co Authors: John J. Jagodnik

Abstract:

There are several ongoing challenges in non-contacting stress measurement systems (NSMS) that have limited the applicability of this technology for general purpose blade health monitoring. Two of the most pressing needs to address are the undersampling that is inherent in time-of-arrival data processing and the uncertainty that is introduced by inferring the mode of vibration. This paper describes new technology that addresses the limitations in current NSMS systems by using an innovative continuous monitoring system with the following capabilities:

• Provides a continuous time series of blade displacement data over a portion of a revolution (solving the undersampling problem).

• Includes data reduction algorithms to directly calculate the blade vibration frequency, modal displacement, and vibratory stress (solving the mode inference problem).

• Uses a single sensor per stage to monitor all of the blades on the stage.

Design and development of the system is discussed. Validation data is presented from a series of tests on compressor rig and spin pit bladed disk.

Ser: 63 **Session:** 3 B Material Health Management

Presenting Author: Jürgen Schreiber

Organization: Fraunhofer-Institute for Non-destructive Testing, Dresden Branch

Country: Germany

Paper Title: Characterization of Fatigue Damage and Residual Life Time Assessment by Fractal Analysis of the Deformation Structure

Co Authors: Ulana Cikalova and Norbert Meyendorf

Abstract:

Today's commercially available component surveillance systems to assess fatigue damage state and the prediction of the residual service life have a substantial drawback, since they require knowledge about the current material stage or load history. Hence, nondestructive testing (NDT) methods are desired that are able to estimate the fatigue life of component materials practically and reliably. Mesomechanics provides a new approach to evaluate materials damage based on the analysis of deformation structures during fatigue. Stress concentrators occur locally in inhomogeneous materials, which can cause a gliding process along net- plains, formation, and slip-bands, for example. These effects can be accompanied by a three-dimensional rotation of bordering materials, e.g. whole grains. As a result, new stress concentrators will be produced at locations far from the initial point of deformation. When the load process starts, translation-rotational processes are initiated on the microscopic structure level. Then, increasing loads or loading-time similar processes can be observed on higher structure levels, and new structural elements, such as vortices or glide bands may occur. Finally, this results in the development of hierarchical structures. A new NDE approach, based on the hypothesis that the deformation structure is of fractal nature and the corresponding fractal dimension DF should be a suitable parameter to characterize structure variations at different damage stages is suggested. Various approaches have been discussed to determine this parameter experimentally.

Based on these ideas, a new nondestructive testing method estimating the residual service life of critical steel components has been suggested. This method determines the time-related scaling behavior of Barkhausen noise signals. The analysis of a significant number of materials provided promising results. Especially for ferritic steel components, a characteristic step-like dependence of the fractal dimension DF as a function of the cyclic load number N divided by the cycle number to fracture NB was found. This concept was developed in the framework of reactor safety research. Later it was applied in different industrial fields, e.g. for testing components of a brown coal overburden conveyor bridge and rolling bearing segments. An inspection system to estimate the residual life time using the above discussed principles has been developed and will be presented.

Recently attempts were made to transfer the fractal concept to non-magnetic materials, especially to Al- and Ti-alloys for aircraft and to widely used stainless steel. For that purpose pulsed eddy current method, sampling phased array technique for ultrasonic backscattering and a new procedure of thermal activated Speckle dynamics were applied. Results of these investigations will be presented in the present contribution.

Ser: 73 **Session:** 3 D Business Cases/Economic Benefits/ Performance Based Logistics

Presenting Author: Gregory Kott

Organization: Xerox Innovation Group

Country:

Paper Title: Estimating Prognostic Benefit for High Valued Components in Repairable Systems

Co Authors:

Abstract:

For years, Xerox has been considered the benchmark for post-sales services in the printing industry. Post-sales services provide over 60% of the company's revenue as most customers who purchase a Xerox system also purchase maintenance service agreements. In the current environment of increasing competition and difficult economic times, it has become increasingly important to improve post-sales service by reducing costs and maximize operational availability.

Preventive maintenance strategies have always been used for high valued components and represent one area where new methods are frequently investigated for improvement. Originally, preventive maintenance strategies were developed for components based on data from an entire population of machines for each product. Data is becoming increasingly available at the individual machine level making it possible to implement unique strategies for subpopulation of each product. As we continue this trend, the goal is to have unique preventive maintenance strategies for each machine based on the customer's mode of operation and stress level.

A key enabler to this goal is continual improvement of our prognostics capabilities for accurately estimating remaining life of components and systems. New preventive maintenance strategies, however, must show a direct cost benefit. Without cost benefit, even the best new maintenance strategies have little hope of moving from research to implementation. To this end, modeling component prognostics and preventive maintenance strategies and estimating their benefit is an important area required to help make this transition.

One method often used to evaluate the benefits of preventive maintenance strategies has been to create discrete event simulation models based on component and system behavior. Inputs include component and system failure distributions and the associated service costs. Models account for system interactions and maintenance rules, and the simulations run for a prescribed system life or mission time. Results include the average cost and operational performance of the components and the system accumulated for each run. These models are readily available and known as Repairable System Models in reliability engineering.

This talk describes a methodology for expanding a standard repairable system model to include prognostic capabilities and a means to estimate the cost benefit. Typically, component and system events are sequenced in chronological order. The impact of prognostic information can be added to the event simulation steps, affecting how the simulation progresses and its results. By expanding our simulations in this way, we can now better understand prognostic information from a cost benefit perspective. And with this new level of information, we can now work toward preventive maintenance strategies which allow for a greater cost benefit as well as increased operational availability for the customer.

Ser: 31 **Session:** 3 D Business Cases/Economic Benefits/ Performance Based Logistics

Presenting Author: Joel Luna

Organization: Frontier Technology Inc

Country:

Paper Title: Consideration of Tangibles and Intangibles to Show Economic Benefit of Prognostics and Health Management

Co Authors:

Abstract:

The capability to obtain reliable and actionable indications of individual component or system failure before the failure actually occurs is generally regarded as a promising enabler for improving operations, maintenance, and supply support of complex systems. While much of the focus on this capability is oriented towards technology (i.e., sensors and algorithms), much less focus has been on how the capability of indications of future failure can be integrated into and positively impact operations and support. While previous efforts have addressed how to conduct a cost benefit analysis, very little has been done on characterizing the relationship of metrics and cost factors for prognostics. It is the goal of this paper to first define a general framework for what benefits can result from implementing prognostics, and then identify relevant prognostic metrics and cost factors and the relationships between them.

Ser: 75 **Session:** 3 D **Business Cases/Economic Benefits/ Performance Based Logistics**

Presenting Author: Paul Howard

Organization: Paul L Howard Enterprises

Country:

Paper Title: NDIA EHM Study Report

Co Authors:

Abstract:

Ser: 72 **Session:** Special Presentations

Presenting Author: Ken Anderson

Organization: Universal Synaptics Corp

Country:

Paper Title: Intermittent Fault Detection and Isolation System Expanding Role

Co Authors:

Abstract:

There is a growing problem that threatens the airworthiness, mission readiness and safety of aircraft. However, recent technical developments have made possible a new inspection method that greatly mitigates this threat, and now multiple case studies are validating the effectiveness of this new capability. The growing problem is intermittent faults in new and aging aircraft electronic boxes. The recent development is the Intermittent Fault Detection and Isolation System (IFDIS), and the case studies that are validating the IFDIS thus far involve two F-16 AN/APG-68 radar system electronic boxes. Maintenance personnel well know the challenge they face when the pilot reports that a system malfunctioned during flight, but the subsequent ground test of that system shows “No Fault Found” (NFF). It is apparent that there is an intermittent problem somewhere in the system, but the frustrated maintenance crew simply lacks the equipment needed to enable them to detect and isolate the problem. Repairing the intermittent circuit is seldom difficult; the difficult task is detecting and isolating which circuit within the box is intermittent. An intermittent fault, or momentary “open,” can be due to a number of different conditions including a cracked solder joint, a corroded contact, a sprung connector receptacle, a loose crimp connection, a hairline crack in a printed circuit trace, a loose wire wrap, a broken wire, or various other conditions. As the electronic boxes are pulled from the errant system for bench test, they often all test NFF. No repair is performed, because no problem can be detected. Conventional test equipment is simply not designed to detect intermittent circuits. Rather, conventional equipment is designed to test the electronic box for nominal operation, and it usually “averages out,” and hence hides, any short term anomalous events. The IFDIS is a tester that was specifically designed to detect and isolate intermittent circuits in electronic box chassis. Hence, the IFDIS very effectively compliments conventional testers. The conventional testers test for nominal equipment operation, while the IFDIS detects and isolates intermittent circuits. Because intermittent faults often only occur during the vibration and/or temperature extremes experienced in an operational environment, the IFDIS includes an environmental chamber and vibration platform that subjects the box to simulated operational conditions, substantially enhancing the probability an intermittent circuit will manifest itself. At the heart of the IFDIS is state of the art intermittent fault detection circuitry which continuously and simultaneously monitors every single electrical path in the chassis under test, while the box is exposed to the simulated operational environment. The intermittent fault detection analog neural network circuitry will detect when an intermittent event, even as short as 50 nanoseconds (0.00000005 seconds), occurs in any chassis circuit, and it identifies in which circuit the intermittent event occurred. Over 100 radar radio frequency boxes and dozens of interconnecting antenna unit ribbon cables have been tested to date with unprecedented results. Previously undetectable problems are being rapidly identified and repair shop troubleshooting time is being substantially reduced. More importantly, the IFDIS is significantly enhancing aircraft reliability, airworthiness, mission readiness and safety.

Ser: 71 **Session:** Special Presentations

Presenting Author: Nicholas Goodman

Organization: University of South Carolina

Country:

Paper Title: Innovations from CBM Research including the Business Case Analysis

Co Authors: Dr Abdel E Bayoumi ??

Abstract:

Traditional Condition Based Maintenance programs typically rely on pre-existing knowledge of component failure modes and specifically tailored condition indicators to maximize the cost effectiveness of the hardware and analysis. In certain critical operating environments, however, it can be seen that deployment of such technologies can be cost effective, even when the success rate of the diagnostics is low. In the case of US Army Aviation, Health and Usage Monitoring Systems have been deployed on a wide variety of platforms, even though critical limits for particular condition indicators had not been established. This alternative approach to CBM requires significant post-processing and development of condition indicators, as well as component testing to validate suspected failure mode signatures. The ongoing laboratory research has provided a number of examples in which the pre-implementation approach to CBM has created significant findings of scientific and economic value, and particular highlights from these findings are discussed.

Ser: 15 **Session:** Special Presentations

Presenting Author: Phil Dussault

Organization: US Army AMRDEC Diagnostic/Prognostic Lab

Country:

Paper Title: How Opportunistic is it for Prognostics Products to Transition?

Co Authors:

Abstract:

The Department of Defense has discussed system health management in many forms. Maintaining the systems and equipment that protect our troops has never seen more visibility and support, but not necessarily the budget to effectively deliver. The latest form of system health management is an augmentation that employs prognostic measures to determine probability of a successful mission. As a practitioner in the dark arts and skullduggery of measurement based diagnostics and prognostic health management (PHM), one finds this to be outstanding, wonderful, and stupendous. All the great adjectives to say how great this pronouncement is with no real measure of effectiveness. This paper will show that while the intent for prognostics in our logistics programs is there, the perception of what that means is all over the map. This paper will develop opportunities for the system acquisition, capability requirements, science and technology communities to come together to develop the necessary standards and definitions to address prognostics as a logistics enabling multiplier. Before we can adequately define the PHM related needs, we must first understand some of the maintenance and logistical shortfalls that presently exist in aviation, ground, and missile systems. In cooperation with the PMs and Users, we want to determine the components and systems that will benefit most from PHM Technology. The paper will discuss current initiatives and the opportunities to address these shortfalls and reduce the burden on our soldiers. Such an initiative is ongoing within the Army's Research Development & Engineering Command (RDECOM). RDECOM has established System Integration Domains (SIDs) and Technology Focus Teams (TFTs) to reach across the acquisition, user, and technology communities to capture and address any shortfalls in capability needs for our warfighters. Our focus is to make sure we are communicating the future needs early enough, but also planning for evolutionary transition to each phase. Finally, the paper will address questions, such as, "How do we get the PHM Technology into the hands of our soldiers/customers to help them plan maintenance activity, know the health status of the fleet at appropriate levels of management, and how do we optimize the data management requirements to perform the analysis necessary to implement programs such as Condition Based Maintenance (CBM+)?" "How do we plan for future needs while delivering the best components/practices now?" "How good is good enough for a prognostic system to be initially fielded then later refined as the system learns how to improve in confidence?"

Ser: 18 **Session:** 4 A Health Management Strategies

Presenting Author: Richard Holmes

Organization: VEXTEC Corporation

Country:

Paper Title: Small Turbine Engine Testing for Cost-Effective Health Prognosis

Co Authors: Thomas Brooks

Abstract:

The reliability of jet engine components is influenced by the extreme conditions in which they operate. Fatigue related failure of a jet engine component such as a turbine disk can arise from several mechanisms. Just as with many other high speed rotating systems, current safety regulations require gas turbine engines to satisfy both crack initiation (safe-life) and fatigue crack growth (damage tolerant) design criteria. In an attempt to satisfy these requirements, non-destructive inspection techniques such as fluorescent penetrant, eddy current, and ultrasonic inspections have been implemented to detect small cracks at critical locations. These approaches, which rely on systematic inspections of critical life-limiting locations in components, detect cracks that can potentially grow to failure within the next inspection interval. However, such non-destructive inspections cannot be performed in-service and require a complete disassembly of the engine. Advanced and efficient life management practice and increased time-on-wing will be achieved by implementing new diagnostic and prognostic systems. These prognosis systems rely on close coupling between sensors and component material failure prediction methods. VEXTEC's scaled engine testing capabilities fills the void between bench scale testing and full rig testing by providing small scale testing under realistic operating conditions in a timely and cost effective manner. This capability provides manufacturers with the opportunity to evaluate changes in materials, manufacturing processes, design loads, and operating conditions in a fully instrumented environment. These capabilities, when combined with VEXTEC durability simulations and failure prediction methods provide comprehensive understanding of the complexities inherent in the extreme operating conditions of real components. The VEXTEC durability simulation methods incorporate newly developed physically based probabilistic models that describe damage evolution under service conditions. The models are based on key damage mechanisms including three dimensional crack growth in components, nonlinear material behavior and complex mission loading.

Ser: 20 **Session:** 4 A Health Management Strategies

Presenting Author: Sonia Vohnout

Organization: Ridgetop Group, Inc.

Country:

Paper Title: Autonomic Integrated Prognostics Health Management Systems: Concepts and Designs

Co Authors: Byoung Uk Kim, Chris Lynn, Neil Kunst

Abstract:

The current state of the art in health management systems does not fully support the detection, collection, and remediation of real-time faults in mission critical platforms. This has led researchers to consider alternative health management paradigms and techniques that are based on strategies used by biological systems to deal with complexity, dynamism, heterogeneity, and uncertainty. In the proposed autonomic health management paradigms, data on multiple characteristics will be sequentially collected from various components and/or subsystems from different levels of the system. Our autonomic health management paradigm explained in this paper utilizes this collected sensor data, which handles uncertainties and anomalies, and realizes systems and subsystems capable of managing themselves with minimal human involvement. We successfully showed the initial results for fault detection with effective sensor monitoring and critical distinction between normal and abnormal status in power supply system.

Ser: 47 **Session:** 4 A Health Management Strategies

Presenting Author: Brian Bole

Organization: Georgia Tech

Country:

Paper Title: Automated Contingency Management (ACM) for Overactuated Systems

Co Authors: Douglas Brown, and George Vachtsevanos

Abstract:

A model for three DC motors geared to the same output shaft is used to demonstrate the ACM control problem for a general over-actuated system. A standard insulation breakdown model is used to estimate the health of each of the motors windings. The ACM architecture will distribute control effort among multiple effectors to minimize the error in following a mission profile while not allowing any of the components to become damaged beyond a given threshold for the duration of the mission. Some initial difficulties in controlling the three motor system are overcome using a dynamic inversion calculation. Finally, an optimal control is approximated by quantizing the space of possible control sequences and performing a search.

Ser: 51 **Session:** 4 A Health Management Strategies

Presenting Author: Geoffery Zhang

Organization: Intelligent Automation, Inc.

Country:

Paper Title: Agent-based Automated Algorithm Generator

Co Authors: Roger Xu, Xiong Liu, Margaret Lyell, and , Xiaodong Zhang (Wright State University) James Bechtel (Army)

Abstract:

The variability of vehicles poses a great challenge on the diagnostics and prognostics for the whole fleet with a vast number of Army ground vehicle platforms. A general diagnostics/prognostics model does not exist and it is difficult to select the best algorithm from a large amount of candidate algorithms for each specific component/subsystem/system application. Therefore, it is necessary to develop a unified framework to evaluate and select the best algorithms, and further maintain the on-vehicle algorithms by updating algorithm parameters and integrating new fleet-wide vehicle data statistics and trends. To address this problem, we propose an agent-based automated algorithm generator for fleet-wide diagnostics/prognostics, which can automatically generate the most suitable algorithm(s) for each vehicle or component in the fleet from a library of light-weight diagnostic/prognostic algorithms. When sufficient fleet-wide statistics and trending information are available, the automated algorithm generator server will automatically determine whether it is necessary to update the current vehicle algorithm configuration or select a better algorithm for on-vehicle diagnostics/prognostics. To prove the concept, we used battery diagnostics as an example to demonstrate the algorithm selection & generation process, and updating capabilities in a networked agent environment.

Ser: 57 **Session:** 4 A Health Management Strategies

Presenting Author: Dennis Moore

Organization: RJ LeeGroup Inc

Country:

Paper Title: Realizing The Value: Transitioning a Proof of Concept Prototype into a Fully Functional Product

Co Authors:

Abstract:

Integration of technology is often a challenging process. Underlying research that drives technology advances can take months or even years to realize. While research opportunities continue to be discovered, the developed intellectual property is ever changing and advancing. Similarly information technology is ever changing driven by Moore's Law (Moore, 1965) following a pattern called the 18 month rule. The goal then is to deteremine the right mix of technologies that accommodate for future growth and which won't become obsolete in the short term.

Following on from the paper developed by Standard Aero in which they discuss the realization of goals related to a Reliability Centered Maintenance set of workscope decision support tools, this paper will discuss methods and strategies used to ensure the integration of those tools into a production system that both accommodates for future growth and avoids pitfalls that drive "The Never Ending Project".

"The Never Ending Project" is a moniker given to projects that seem to hit a peak. Unfortunately, once that peak is achieved the laws of diminishing returns steps in and nearly brings projects to a screeching halt. This project killer has been the death of many great ideas that seem to languish when it comes to practical implementation.

Given RJ LeeGroup's experience in both public and private sector research projects, RJ LeeGroup has the proven capability designing, implementing and integrating high technology solutions for our customers to support the realization of the value proposition offered by R&D efforts.

Ser: 67 **Session:** 4 A Health Management Strategies

Presenting Author: Leandro Barajas

Organization: General Motors R&D Center

Country:

Paper Title: A Survey on Prognostic Metrics

Co Authors: Tsai-Ching Lu(1), Narayan Srinivasa(1), and Leandro G. Barajas(2) (1) Information and System Sciences Laboratory, HRL Laboratories, LLC, Malibu, CA 90265, USA {tlu@hrl.com,nsrinivasa@hrl.com} (2) Manufacturing Systems Research Laboratory, GM R&D Center, Warren, MI 48090, USA, {Leandro.Barajas@gm.com}

Abstract:

Prognosis is the process of prediction and diagnostic of what events will occur when during the course of a sequence of event occurrences. In this survey, we focus on prognostic metrics for evaluating prognosis systems, rather than discussing or benchmarking various prognosis algorithms. The goal is to assist readers in choosing the appropriate prognosis metrics for system performance evaluation. The scope of our survey includes metrics for dichotomous, categorical, continuous variables with forecasts in form of point, rank, probability or distribution. We provide a detailed mathematical description of the various tools and provide an insight via working examples to show how these metrics can be computed. We also identify the advantages and disadvantages of these metrics. We conclude by proposing relevant criteria needed to develop integrated metrics for comprehensive prognosis. This survey shows that most metrics focus on the evaluation of the prediction for what is going to occur, only a few focus on when are these events more likely to happen; most metrics are population based while only a few are instance specific; most metrics are at single granularity level, none are at an integrated and hierarchical level. This survey finds that prediction-to-failure time and confidence-bound have shown to be highly relevant in recent studies. In particular, the Receiver Operating Characteristic (ROC) analysis with time-dependent, confidence-bound, and multi-category features is a promising candidate for a comprehensive prognosis set of metrics. We expect to see further extensions of ROC analysis for predictions with criteria such as cost, multiobjective, and multi-level in the near future.

Ser: 65 **Session:** 4 C **Systems Engineering and Health Management Applications**

Presenting Author: John Lucero

Organization: NASA John H Glenn Research Center

Country:

Paper Title: The Decision Analysis Process

Co Authors:

Abstract:

In today's complicated world, many possibilities are available to solve a problem. Choosing the most efficient and advantageous solution is very challenging considering all the variables and options presented. An analytical tool is very beneficial for modern man to help evaluate complex issues, alternatives and the inherent uncertainties/risk to support a final choice. This tutorial presents a decision analysis process that can be used by a project for technical management, system design and product realization. This process can be used to evaluate the impact of decisions on cost, performance and schedule on a project. The process will be discussed and immediately following, a real life example will be presented.

Ser: 66 **Session:** 4 C Systems Engineering and Health Management Applications

Presenting Author: John Lucero

Organization: NASA John H Glenn Research Center

Country:

Paper Title: Heavy Lift Launch Vehicle Payload Fairing Structural Concept Down Select Process

Co Authors:

Abstract:

A NASA Project team was chartered to address the challenges, risks, and needs related to the use of composite materials and structural systems technologies for specific space hardware applications. The objective of the Project was to develop mid-technology readiness level (TRL) composite materials and structures technologies to TRL 6 for specific Heavy Lift Launch Vehicle (HLLV) applications. The Project used capabilities from across the Agency to form multi-disciplinary, cross-center teams to meet this objective. In this study several lightweight Payload Fairing (PF) structural concepts are identified that meet the performance levels prescribed by the HLLV system studies. These concepts were then evaluated against specific criterion and compared one to the other. This paper describes the Trade Study process that was used by the Project to select a specific PF Structural Concept for the HLLV.

Ser: 26 **Session:** 4 C Systems Engineering and Health Management Applications

Presenting Author: Radu Pavel

Organization: TechSolve, Inc.

Country:

Paper Title: Machine Tool Health Monitoring Using Prognostic Health Monitoring Software

Co Authors: Loran Miller, John Snyder, Nick Frankle, and Gary Key; Address for Loran Miller and Nick Frankle Frontier Technology, Inc. 4141 Colonel Glenn Highway Suite 140 Beavercreek, OH 45431 Phone: 937-429-3302 Fax: 937-429-3704

Abstract:

The efforts to improve machine tool utilization and effectiveness in manufacturing are strongly dependent on the capability to prevent or minimize downtime. Downtime is strongly related to the health of the machine tool and may result not only in high repair costs, but also in customer dissatisfaction and lower potential sales. Therefore, implementation of advanced health management strategies for the machine tool has become imperative. In industry, the most up to date health management strategies are based on diagnosis and prognosis of component failure using non-destructive and advanced modeling techniques. Diagnostic systems and condition-based maintenance (CBM) software have been successfully implemented for ground vehicles, marine systems, aerospace, and energy systems. However, despite the success recorded in various areas, the application of health management solutions in manufacturing, particularly for the machine tool, is still very limited. For the past three years TechSolve, Inc. has dedicated resources for the identification, evaluation, and development of technologies focused on diagnostics and prognostics of the health and maintenance of a machine tool. Such technologies can increase machine tool availability and utilization by the ability to predict and prevent costly downtime. Recently, engineers from TechSolve and Frontier Technology, Inc. (FTI) have teamed to study the applicability of FTI's commercially available prognostic software, NormNet®, for a computer numerical control (CNC) machine tool. NormNet® is a data-derived health monitoring system based on FTI's patented Pattern Recognition of Health (PRoH™). The five-stage process minimizes the need for physical models, proprietary information, or detailed system knowledge and requires only currently available data sources and systems. NormNet® utilizes a statistical modeling method to perform system level prognostics to provide early indicators of degradation or machine faults. It can perform health analysis while the equipment is in use, reducing disruptions to normal operations. TechSolve's engineers have developed a system to acquire data from external sensors and from the machine tool's controller. The monitoring system was applied to a Milltronics horizontal machining center (HMC35) with a Fanuc 0i series controller. Monitored data included vibration and temperature at different positions, metalworking fluid flow and pH, and power of the spindle motor. Data from the machine tool control, such as axes position, servo loads, servo delay, and others was also monitored. Following the integration of NormNet®, engineers demonstrated the capability to model normal operations based on a range of system environmental conditions. Using simulated faults, engineers demonstrated the capability to estimate the total system health as well as identify subsystem faults. The study illustrated adaptation and effective use of the NormNet® application for manufacturing equipment. Results and impact are discussed and presented.

Ser: 80 **Session:** 4 C **Systems Engineering and Health Management Applications**

Presenting Author: Daniel Walsh

Organization: Spectro, Inc

Country:

Paper Title: Shape Classification Particle Counting and Emission Spectroscopy for Wear Debris Analysis – Current and Future Trends

Co Authors: Chadha, S

Abstract:

Recent advances in optics technology, algorithm development, and expert analysis systems have led to new analysis tools being introduced to at line/off line oil analysis practitioners, improving the already well known cost-to-benefit ratio of the technology to the equipment maintainer. This presentation outlines these advances and what the demands are from the military and commercial markets in the near future.

Ser: 13 **Session:** 4 D Data/Knowledge Management

Presenting Author: Amit Deshpande

Organization: TechSolve, Inc.

Country:

Paper Title: Cloud Computing Architecture for Manufacturing Data Management

Co Authors: Kevin Bevan, Mark Doyle

Abstract:

Intense global competition has forced many US manufacturers to examine their current business practices as well as evaluate how to meet these challenges and remain competitive. Major emphasis has been placed on disruptive innovation and manufacturing research with recognition of the need to better manufacturing data management, automation, continuous improvement and process optimization through data mining. The benefits of effective Manufacturing Data Management (MDM) include reduced downtime, improved operator productivity, optimal machine scheduling, overall equipment effectiveness, alarm/alert management and better product quality. However small to medium manufacturers do not have the capital and resources needed for the data management technology and cannot justify the return on investment. In addition, the manufacturers have to train personnel, maintain support staff and manage upgrades and maintenance of the applications. In this paper we describe the design, architecture and implementation of the I-LinkTM system on an open architecture constant velocity RevolutionTM controller using the cloud computing architecture. The dynamically scalable resources are externally hosted by a third party and follow a pay-per-use methodology with no software licensing, high service level agreement and secured transactions. The on-demand cost effective cloud computing architecture for MDM is developed as part of the supervisory system thrust area for the Smart Machine Platform Initiative (SMPI). The supervisory system is the system that integrates and coordinates multiple process monitoring and control modules such that a globally optimal machining solution could be delivered real-time for desired quality and maximum productivity. The paper discusses in-depth the implementation architecture, benefits, limitations, security concerns and future work needed to ensure effective manufacturing data management utilizing cloud computing.

Ser: 48 **Session:** 4 D Data/Knowledge Management

Presenting Author: Joe Sheeley

Organization: Arnold AFB, AEDC

Country:

Paper Title: A Survey of Rotating Machinery Condition Indicators

Co Authors: Cory R Duggin

Abstract:

In the interest of reducing unexpected machinery failures and lengthy downtime, while also reducing unneeded maintenance with its cost and possibility of adding faults to systems, Conditioned Based Maintenance (CBM) and Predictive Maintenance (PdM) programs have become prevalent in industry. The next logical step is the adoption of online maintenance, in which data currently collected in routes perhaps weekly or monthly are replaced with data collected as often as every few minutes by a system permanently connected to the system. A critical issue in developing online systems is the automation of initial data screening to reduce the workload of the analysts to review of only critical datasets. To achieve this goal, online facility monitoring systems need to reduce the streams of raw data into a set of condition indicators indicative of the health of the various machine components which need to be monitored. In this paper a review of the literature for condition indicators used to identify common faults is undertaken with the goal of selecting those suitable for use in an automated data screening process. Research results and techniques for fault detection in rotors, journal bearings, rolling element bearings, gear boxes, fans, compressors, and electric motors have been compiled. The uses, common faults, and critical parameters of interest are discussed for each of the components covered.

Ser: 33 **Session:** 4 D Data/Knowledge Management

Presenting Author: Mike Denton

Organization: National Instruments

Country:

Paper Title: Moving Beyond Advanced Analysis to Data Management and Decision Making

Co Authors: Preston Johnson, Kurt Veggeburg

Abstract:

Condition based monitoring systems, and in particular embedded monitoring systems that continuously monitor rotating machinery have three critical tasks. They must acquire the appropriate vibration signals and analyze the raw data to tell us what kind of vibrations we are seeing in the system. Once the proper analysis has been performed the data must be stored in a maintainable way and managed, so that new and old data can be compared and trends can be identified for the machine. Finally the system needs to provide feedback for realistic decisions to be made. Creating a continuous data logger is only the first step in getting the necessary data for describing the behavior of a vibrating machine. Frequency analysis of the data will allow us to characterize how the data is vibrating. Some of the more crucial steps for success here are to take into account the speed at which the machine is rotating, and filtering out acceptable noise to properly isolate and identify the troublesome vibrations. By putting all this information together, we can properly describe the behavior of the machine without an experienced vibration analyst being present. Even if the data is easily acquired it is still crucial to manage that data in such a way that it can be used. The Mimosa standard provides a great starting point, and suggests characterizing the data by plant, machine, sensor and time. Implementing this system is still a challenge, as not only does the raw time waveform data need to characterized, but the frequency analysis that has been performed needs to be saved and associated with the raw time data. Proper management of this data allows comparisons of machine behavior over time. Continuous logging of critical data makes it easy to identify trends in the machines vibrations. This data management can be performed without requiring the development and maintaining of huge database files. Modern searching techniques enable a more flexible and effective solution that can be implemented faster and more easily. Making decisions based on the acquired data is the purpose of the conditioned monitoring system. With the effectively stored data, proper reporting is now possible. Absolute values for machines are very difficult to create. There are so many variables in every installation. A trend based approach allows for better decisions about each individual machine. Understanding which machine vibrations have deteriorated over the past month is much better than knowing which one vibrates the most. Proper steps can be taken to maintain the machine with rising vibrations without unexpected shutdowns and damage. Effective data management and advanced analysis make these predictive trends possible to report. Building a condition monitoring system is challenging and requires several different components to fully realize the benefits. This paper introduces the necessary analyses to perform, then provides an example of how to quickly provide the data management, and finally identifies key trends for a couple machines that can be logged and reported on as the machine approaches failure.

Ser: 45 **Session:** 4 D Data/Knowledge Management

Presenting Author: Matt Sedlak

Organization: RJ LeeGroup Inc

Country:

Paper Title: Web 2.0: Forming a Collaborative Information Enterprise

Co Authors:

Abstract:

Web 2.0 represents a fundamental shift in information management which demands real time, context specific informational content for each individual in the enterprise. Rather than depending on application and database developers to create an organization's informational views, users (i.e. the subject matter experts themselves) are empowered to form their own views of the information that they need (and only what they need). Users can contribute their content back to the enterprise achieving a truly collaborative information enterprise that grows virally. The tools and techniques needed to realize collaborative informational enterprise are here. In this discussion, we will: • Identify the major challenges • Introduce the tools and techniques • Review a case study The goal of this presentation is for audience members to walk away asking themselves two questions: 1. what informational views would make me and my team perform better 2. why don't we have them, now Many of the traditional IT excuses are gone. Getting started is a matter of making the shift in culture to a user driven informational enterprise.

Ser: 78 **Session:** 4 D Data/Knowledge Management

Presenting Author: Randy Torfin

Organization: US Navy Military Sealift Command HQ

Country:

Paper Title: US Navy Military Sealift Command's Maintenance Management Program

Co Authors:

Abstract:

Ser: 28 **Session:** 4 D Data/Knowledge Management

Presenting Author: Renata Klein

Organization: R.K. Diagnostics

Country: Israel

Paper Title: Environment for Processing of Wideband Signals

Co Authors: Eduard Rudyk

Abstract:

Acquisition and analysis of signals from mechanical equipment are necessary steps to achieve the goal of fully automatic diagnostics and prognostics. When some of the data is wide-band, such as signals from vibration and acoustic sensors, the processing stage is computationally intensive and requires a sophisticated handling environment. The article presents a proposed architecture for such an environment. This architecture was developed and used successfully in R.K. Diagnostics. The environment is able to support multiple mechanical systems, different configurations of acquisition equipment, automatic data screening, automatic recognition of operation modes, as well as facilitating flexible flows of algorithms configurable for different combinations of flight regimes, plants, or sensors. Other features of the architecture include providing a simple interface for development of diagnostics and prognostics algorithms, ability to store most of the parameters in external database, and ability to export algorithms to customer embedded platform. The system is OSA/CBM compliant, highly modular, platform independent and flexible. Analysis and illustration of the proposed environment is presented for an application of vibrations data analysis.