Assigned Session: B 1 Health Management Tools and Capabilities

Presenting Author: Jake Siegel **Ser:** 28

Organization: Luna Inc.

Country:

Paper Title: **Nonintrusive Load Monitoring of Rotating Machinery**

Co Authors: Nathan K. Brown, Gheorghe Bunget, Paul Muskopf, Mateja Putic

Abstract:

Regardless of age or service history, machine equipment must be reliable and ready for operations required by test and evaluation schedules. There is a continuous need to increase the service life and reliability of rotating machines, and to reduce their maintenance costs and equipment outages. To this end, condition based maintenance of rotating machinery using embedded instrumentation and sensor networks capable of monitoring critical machine health parameters has proven to be an effective approach for increasing the reliability of rotating machines. Cost effective sensing platforms that can autonomously perform data collection tasks, without increasing the workload of personnel performing scheduled maintenance routines, troubleshooting, and diagnostics, are needed. Currently used hour meters or odometers do not provide indication of when machines ran, for how long, or at what load level, which comprises machine usage life. There is a need for a non-intrusive means of recording motor start and stop times, and for measuring load levels during run-time to provide a historical load profile, which provides an idea of how hard a machine was run and for how long. Such monitoring capabilities, if broadly deployed, would result in operational improvements including increased efficiency of asset resource and reduced time and resource barriers to addition of instrumentation to existing infrastructure. The objective of this paper is to introduce a non-intrusive method of a distributed plant monitoring system that estimates the mechanical load by analyzing the emitted rotating machine energy in the form of vibration, magnetic flux, and heat. Data collected using custom designed, 1 Hp and 5 Hp induction motor test stands show the dependence of a large air core RF coil, small RF coil array, and Hall effect sensor outputs on applied motor speeds and mechanical loads (generator output and torque, respectively). Analysis indicates that the large air core RF coil transducer and the presented method for using non-intrusive collection of induction motor speed and magnetic flux can statistically measure the difference between any two load points with 95% confidence, if their values differ by 6.6% full scale or greater (±2s). The collected vibration, magnetic flux, and thermal data was analyzed and modeled using a data fusion approach in order to estimate machine service longevity. Additionally, areas of further research toward generalization of the approach and scalability for different sized motor applications are identified.

Assigned Session: B 1 Health Management Tools and Capabilities

Presenting Author: David Siegel **Ser:** 7

Organization: University of Cincinnati

Country:

Paper Title: **Reconfigurable Informatics Platform for Rapid Prognostic Design and Implementation: Tools and Case Studies**

Co Authors: Jay Lee

Abstract:

Prior work in the area of developing prognostic and health monitoring systems for various platforms have required considerable development time and resources, and only result in a specific application solution. This paper presents a methodology and suite of informatics algorithm software tools to expedite the time and reduce the trial and error methods used in developing predictive health monitoring systems. The methodology highlights the key aspects in prognostics and health management system development, including data preparation and cleaning, features extraction, health assessment, diagnosis, and health prediction. A discussion of the algorithms for each of these processing modules is provided, including a tabular summary of the relative merits of each of the algorithms. A case study on anemometer sensor health assessment is presented that highlights the various processing modules and the use of a residual clustering health model. An additional case study for aircraft engine remaining useful life prediction using a similarity based prediction method is also included. Overall, the results using the proposed methodology and suite of algorithm tools resulted in quickly developed and accurate prognostic and health monitoring models. Future work is looking at enhancing the suite of prediction algorithms to handle situations with sparse amounts of training data. Additional refinement of the residual clustering method for multi-regime health monitoring applications is also being considered for further study.

Assigned Session: B 1 Health Management Tools and Capabilities

Presenting Author: Chance Kleineke **Ser:** 58

Organization: Engineering Consultants Group, Inc.

Country:

Paper Title: **Health Management of Utility Coal Pulverizers**

Co Authors: Michael Santucci, Rudy Scavuzzo

Abstract:

Coal-fired power plants utilize coal pulverizers in a direct-fire system to grind the fuel to an appropriate fineness just before it enters the boiler. Pulverizer health management is therefore vital in efficient power plant operation. The 2000-2010 North American Electric Reliability Council Generating Availability Data System (NERC/GADS) report indicates that pulverizer-related problems are one of the most frequent causes of partial forced outages in coal-fired power plants. On average, there have been more than ten occurrences per year of forced unit derations caused by pulverizer problems during the five years included in the report. This is by far the largest cause of forced derations in the power plant. Although these outages typically do not result in removal of the unit from service, these problems, including drive shaft failures, excessive component wear, and bearing failures, do increase maintenance expenditures throughout the year. Also well documented is the influence pulverizers have on combustion, NOx formation, unburned carbon and slag. There are several issues that can reduce mill efficiency including, but not limited to: broken springs; worn rolls; roll eccentricity; journal bearing failures; plugged feeder; excessive mill inventory/recirculation. These cases can lead to fatigue failures of larger mill components. Unscheduled mill downtime can lead to unwanted output losses and increased cost. A key concern is main vertical shaft failure due to an unbalanced load from the journals. For large mills, taking into consideration parts, labor and down time, costs related to a main shaft failure can easily exceed $500,000. Instrumenting these mills can prove challenging with the harsh coal environment in which they are located. This paper discusses methods to instrument and monitor pulverizers utilizing Advanced Pattern Recognition (APR) to mitigate common failure modes. Continuous monitoring of the mills aids in condition based maintenance programs and provides early detection of deteriorating conditions.

Assigned Session: B 1 Health Management Tools and Capabilities

Presenting Author: John Lacontora **Ser:** 77

Organization: Drexel University

Country:

Paper Title: **Extending Rotorcraft Component Lives Using IMS Tools**

Co Authors:

Abstract:

Over last two decades Intelligent Maintenance Systems (IMS) have emerged as an enabler for manufacturers and owners of complex systems to significantly increase their systems' reliability and lower the overall cost of ownership. IMS health monitoring and analyses tools have the potential to determine the remaining useful life of components and subsystems resulting in a considerable reduction in operation and maintenance costs. This presentation addresses the issues associated with granting credits to extend rotorcraft life limited components useful life.

Assigned Session: B 1 Health Management Tools and Capabilities

Presenting Author: Stephen Wnuk **Ser:** 59

Organization: NASA Planning and Integration Office

Country:

Paper Title: **Evaluation of Data-Logging Transducer to Passively Collect Pressure Vessel P/T History**

Co Authors:

Abstract:

Pressure vessels owned and operated by NASA are required to be regularly certified per agency policy. Certification requires an assessment of damage mechanisms and an estimation of vessel remaining life. Since detail service histories are not typically available for most pressure vessels, a conservative estimate of vessel pressure/temperature excursions is typically used in assessing fatigue life. This paper details trial use of a data-logging transducer to passively obtain actual pressure and temperature service histories of pressure vessels. The approach was found to have some potential for cost savings and other benefits in certain cases.

Assigned Session: B 1 Health Management Tools and Capabilities

Presenting Author: Rajeev Verma **Ser:** 6

Organization: Cranfield Boeing IVHM Centre

Country: UK

Paper Title: **Functional Modelling of Electricity Frequency Changers to Aid Better Maintenance Practises in Marine Dockyard Facilities**

Co Authors: Dr Ip- Shing Fan Professor Ian Jennions

Abstract:

This paper reports on a failure risk model for electricity frequency changers in marine dockyard operations. Commercial and naval vessels calls at international ports and when a vessel berths in a port the propulsion engines are turned off but normally it would require continuous power to run all of the on board “auxiliaries” such as air conditioning, heating, lighting, battery charging, communications centre, computers, navigation system, water pumps and other utility services. The port and harbour operators offers visiting vessels the opportunity to “plug into” the local power supply grid on the dockside to meet above mentioned requirements so the on board diesel engine generators can be turned off while the vessel is in port. For example NATO ships runs on 110V, 60 Hz power supply and UK power supply is 220 V, 50 Hz. The problem is that marine vessels uses 110V, 60 Hz and hence in this situation frequency changers are used to converts alternating current of one frequency to alternating current of another frequency to meet the requirements. These frequency changers are critical assets to dockside operations and hence require an optimised maintenance program which can ensure their safe working and maximum availability. Frequency changers have a complex integrated design. Identification of probable / possible failures or problems in frequency changer system and their criticality coupled with maximising lead time or unscheduled maintenance can help to achieve maximum safety and availability. A commercially available tool MADe (Maintenance Aided Design) will be used for the identification of the critical components and their effect on overall performance of the system. This research paper is focussed to show how effectively functional modelling techniques can be used to capture the failure modes and failure criticality of each component of frequency changers in order to evaluate system performance. This analysis informs a marine naval dockyard operation on the opportunities to add Integrated Vehicle Health Management (IVHM) features on the frequency changers and improvements optimise to the operations and maintenance actions through its whole life cycle. The concept of dependency modelling will be used to build relationship between systems behaviour and failure modes. A functional system model will be generated to predict the frequency changer system response to component level faults and their criticality. This analysis will be used to identify the critical components for advising necessary maintenance actions to optimise the frequency changer operations through its whole life cycle. The maintenance actions ranges from the human inspection to complex sensor based health management systems. This analysis helps in making the choice, balancing the operations benefits and risks against engineering criticality asset life history.

Assigned Session: B 1 Health Management Tools and Capabilities

Presenting Author: Kevin Melcher **Ser:** 84

Organization: NASA Glenn Research Center

Country:

Paper Title: **Software Tools to Support the Assessment of System Health**

Co Authors:

Abstract:

This presentation provides an overview of three software tools that were developed by the NASA Glenn Research Center to support the assessment of system health: the Propulsion Diagnostic Method Evaluation Strategy (ProDIMES), the Systematic Sensor Selection Strategy (S4), and the Extended Testability Analysis (ETA) tool. Originally developed to support specific NASA projects in aeronautics and space, these software tools are currently available to U.S. citizens through the NASA Glenn Software Catalog. The ProDiMES software tool was developed to support a uniform comparison of propulsion gas path diagnostic methods. Methods published in the open literature are typically applied to dissimilar platforms with different levels of complexity. They often address different diagnostic problems and use inconsistent metrics for evaluating performance. As a result, it is difficult to perform a one-to-one comparison of the various diagnostic methods. ProDIMES solves this problem by serving as a theme problem to aid in propulsion gas path diagnostic technology development and evaluation. The overall goal is to provide a tool that will serve as an industry standard, and will truly facilitate the development and evaluation of significant Engine Health Management (EHM) capabilities. ProDiMES has been developed under a collaborative project of The Technical Cooperation Program (TTCP) based on feedback provided by individuals within the aircraft engine health management community. The S4 software tool provides a framework that supports the optimal selection of sensors for health management assessments. S4 is structured to accommodate user-defined applications, diagnostic systems, search techniques, and system requirements/constraints. One or more sensor suites that maximize this performance while meeting other user-defined system requirements that are presumed to exist. S4 provides a systematic approach for evaluating combinations of sensors to determine the set or sets of sensors that optimally meet the performance goals and the constraints. It identifies optimal sensor suite solutions by utilizing a merit (i.e., cost) function with one of several available optimization approaches. As part of its analysis, S4 can expose fault conditions that are difficult to diagnose due to an incomplete diagnostic philosophy and/or a lack of sensors. S4 was originally developed and applied to liquid rocket engines. It was subsequently used to study the optimized selection of sensors for a simulation-based aircraft engine diagnostic system. The ETA Tool is a software-based analysis tool that augments the testability analysis and reporting capabilities of a commercial-off-the-shelf (COTS) package. An initial diagnostic assessment is performed by the COTS software using a user-developed, qualitative, directed-graph model of the system being analyzed. The ETA Tool accesses system design information captured within the model and the associated testability analysis output to create a series of six reports for various system engineering needs. These reports are highlighted in the presentation. The ETA Tool was developed by NASA to support the verification of fault management requirements early in the Launch Vehicle process. Due to their early development during the design process, the TEAMS-based diagnostic model and the ETA Tool were able to positively influence the system design by highlighting gaps in failure detection, fault isolation, and failure recovery.

Assigned Session: C 1 Diagnostics

Presenting Author: Yongzhi Qu **Ser:** 24

Organization: University of Illinois at Chicago

Country:

Paper Title: **Gear Fault Detection Using Acoustic Emission Spectrum Kurtosis**

Co Authors: Yongzhi Qu, Eric Bechhoefer, NRG Systems

Abstract:

Even though acoustic emission (AE) has been studied as a potential information source for machine fault diagnosis over many years, applications of AE sensors to gear fault diagnosis have been limited due to the lack of effective and efficient AE data analysis techniques. In this paper, a frequency reduction technique is proposed to preprocess the AE signals. Heterodyne technique commonly used in communication is first employed to preprocess the AE signals before sampling. By heterodyning, the AE signal frequency is down shifted from several hundred kHz to below 50 kHz. This reduced AE signal sampling rate is comparable to that of vibration signals. After preprocessing, time synchronous average (TSA) is calculated and spectrum kurtosis (SK) is estimated for the calculated TSA signals as AE features for gear fault detection. An optimal band pass filter based on SK is designed to filter the signals and to extract features for fault detection. The presented method is validated using seeded gear fault tests on a notational split torque gearbox. The method presented in this paper is physics based and the validation results have showed that it could effectively detect the gear faults.

Assigned Session: C 1 Diagnostics

Presenting Author: Kahlil Detrich **Ser:** 67

Organization: SpectraQuest

Country:

Paper Title: **The Interference of Variable Frequency Drives (VFDs) on the Vibration Signature Analysis of Machine Defects**

Co Authors: Nader Sawalhi, Suri Ganeriwala

Abstract:

VFDs are the most commonly used modes to drive induction motors in applications requiring speed variations. However, vibration analysis for fault diagnosis of such systems poses serious challenges as the signatures are complicated due to the inherent design of the VFD. This paper will explain the basic operation of a typical VFD and present vibration signatures of machines operated using VFDs. VFDs control motor speed by varying the supplied line frequency. This is done in three stages. Firstly, the line voltage signal is rectified via diodes to obtain a DC signal. This is then smoothened and stored using a set of capacitors. Finally, the constant DC voltage is used to construct a pseudo AC voltage using a set of transistors, which act like switches (gates). The switching frequency, or carrier frequency, is typically set in the range from 2- 15 kHz. The vibration content as a result of using the VFD contains peaks of discrete frequencies spaced at the carrier frequency and its harmonics. Each peak also contains sidebands around the carrier frequency (and its harmonics) spaced at both the rotor speed and the VFD frequency. Analysts examining high frequency content of their data signals needs to be aware of the carrier frequencies and the associated side bands of their VFD.

Assigned Session: C 1 Diagnostics

Presenting Author: Surya Kunche **Ser:** 66

Organization: SpectraQuest Inc

Country:

Paper Title: **Optimized Diagnostic Model Combination for Improving Diagnostic Accuracy**

Co Authors: Chaochao Chen, Michael G. Pecht

Abstract:

Identifying the most suitable classifier for diagnostics is a challenging task. In addition to using domain expertise, trial and error method has been widely used to identify the most suitable classifier. Classifier fusion can be used to overcome this challenge and it has been widely known to perform better than single classifier. Classifier fusion helps in overcoming the error due to inductive bias of various classifiers. The combination rule also plays a vital role in classifier fusion, and it has not been well studied which combination rules provide the best performance during classifier fusion. In this work, we develop an approach for ensemble learning consisting of an optimized combination rule. The generalizability has been acknowledged to be a challenge for training a diverse set of classifiers, and optimal balance between bias and variance errors using the combination rule in this paper. Generalizability implies the ability of a classifier to learn the underlying model from the training data and to predict the unseen observations. In this paper, cross validation has been employed during performance evaluation of each classifier to get an unbiased performance estimate. An objective function is constructed and optimized based on the performance evaluation to achieve the optimal bias-variance balance. This function can be solved as a constrained nonlinear optimization problem. Sequential Quadratic Programming based optimization with better convergence property has been employed for the optimization. We have demonstrated the applicability of the algorithm by using support vector machine and neural networks as classifiers, but the methodology can be broadly applicable for combining other classifier algorithms as well. The method has been applied to the fault diagnosis of analog circuits. The performance of the proposed algorithm has been compared to other combination rules in the literature. It is observed that the proposed combination rule performs better in reducing the number of! false

Assigned Session: C 1 Diagnostics

Presenting Author: Haiqin Wang **Ser:** 71

Organization: The Boeing Company

Country:

Paper Title: **Automatic Construction of Diagnostic Bayesian Network Models from Airplane Maintenance Manuals**

Co Authors: Oscar Kipersztok

Abstract:

Intelligent diagnosis of airplane mechanic failures using Bayesian network framework has been proven successful with great technology and business potentials. However, with lack of efficient tools of building high-quality Bayesian network models, the modeling process becomes a bottleneck to broad deployment of this technology. The foremost problem lies in the fact that direct knowledge elicitation from domain experts is notoriously time-consuming and expensive. Automatic methods for building these models can significantly reduce the time of modeling process, and also, eliminate the inconsistency involved in the knowledge elicitation. One such method is to extract the domain knowledge documented in airplane maintenance and fault isolation manuals in various formats. These manuals are a rich resource of knowledge for airplane failure diagnosis. We studied many of the maintenance manuals and found that it is possible and reliable to automatically extract the domain knowledge from the documents for diagnosis modeling. We developed a method for converting documents in Standard Generalized Markup Language (SGML) format, identifying the objects for diagnosis and translating those, automatically, into the components of the Bayesian networks. We also extracted the fault explanation and the description of fault isolation procedure and encoded them automatically into the Bayesian networks. The method allows us to quickly generate diagnostic Bayesian networks for many subsystems of various airplane models. Our method allows for building high-quality diagnostic models at the least cost and time by reducing the involvement of knowledge engineering to the possible minimum.

Assigned Session: C 1 Diagnostics

Presenting Author: Joe Sheeley **Ser:** 8

Organization: Arnold Engineering Development Center (AEDC), US Air Force

Country:

Paper Title: **Clustering Techniques for Machinery Fault Classification**

Co Authors:

Abstract:

For many years machinery monitoring software has merely provided tools for data review with rudimentary alarming capabilities based upon the Root Mean Squared (RMS) level of the vibration waveform signal and the level of various spectral peaks in the spectrum of the vibration signal. While many faults can be detected by looking at the levels of RMS and spectral peaks, there are other factors such as kurtosis, skew, and sideband level factor that may indicate faults that the more established indicators cannot. In addition, looking at factors independently may be less effective than looking at multiple factors at the same time, particularly when attempting to automate some of the diagnostic procedure. For example, both imbalance and misalignment will cause an increase in the vibration at the once-per-revolution frequency, but only imbalance will also cause an increase at the twice-per-revolution frequency. This paper will present various clustering techniques that can be used to automatically find how condition indicators cluster together for various operating and health states of machinery being monitored.

Assigned Session: C 1 Diagnostics

Presenting Author: Afshin DaghighiAsli **Ser:** 2

Organization: Morvarid Petrochemical Complex

Country: Iran

Paper Title: **Analyzing Imbalance in a 24 MW Steam Turbine**

Co Authors: Vahid Rezaie, Leila Hayati Mopsaco Consulting Company

Abstract:

Imbalance in critical rotary equipments is one of the most important factors which should be controlled to prevent great damages. In this case-study a 24 MW steam turbine is discussed which drives a propane compressor. The radial vibration on the DE side of the turbine grew gradually to a high level close to it's alarm's value. Using FFTs, time signals, orbit diagrams, and phase measurement led to believe that the rotor became imbalanced. After tripping and disassembling the turbine, It was found out that some blades of the impulse stage of HP section got broken. Changing the rotor with the spare one, and repair the damaged rotor, worked out. It was concluded that using vibration analysis technique is an effective method to find critical rotating equipment's faults at the earliest levels. And performing the essential correcting tasks lead to prevent secondary damages and specially decrease of production.

Assigned Session: C 1 Diagnostics

Presenting Author: Yan Chen **Ser:** 82

Organization: United Technologies Research Center

Country:

Paper Title: **Performance Evaluation of a Second-Order Indicator of Cyclostationarity for Gear Condition Monitoring**

Co Authors: Yan Chen, Zaffir Chaudhry, and Paula Dempsey

Abstract:

This paper compares the performance of a second-order indicator of cyclostationarity for gear condition monitoring to that of conventional condition indicators which are based on the time synchronous average. The second-order indicator of cyclostationarity is obtained through computationally-efficient analysis of the portion of the signal that remains after the time synchronous average has been subtracted from the signal. Four gear vibration data sets produced on the spiral bevel gear test rig at NASA Glenn Research Center were analyzed. The second-order indicator of cyclostationarity was competitive with the RMS and FM4 condition indicators in providing effective detection of gear damage, and offered superior performance in isolating gear damage in gear/pinion pairs.

Assigned Session: D 1 Wind Turbines

Presenting Author: Eric Bechhoefer **Ser:** 4

Organization: NRG Systems

Country:

Paper Title: **Analog Signal Processing to Improve Acoustic Emissions Sensing**

Co Authors: Yongzhi Qu, Junda Zhu, and David He

Abstract:

Acoustic Emissions (AE) are stress waves produced by the sudden internal stress redistribution of material caused by changes in the internal structure of the material. Possible causes of these changes are crack initiation and growth, crack opening/closure, or pitting in monolithic materials (gear/ bearing material). Where as vibration can measure the effect of damage, AE is a direct measure of damage. Unfortunately, AE methodologies suffer from the need of high sample rates (4 to 10 Msps) and relatively immature algorithms for condition indictors (CI). This paper hypothesizes that the AE signature is the result of some forcing function (e.g. periodic motion in the case of rotating machinery). As such, by demodulating the AE signature, one can reconstruct the information carried by the AE signature and provide improved diagnostics. As most on-line condition monitoring systems are embedded system, analog signal processing techniques are proposed which reduce the effective sample rate needed to operate on the AE signal to those similarly found in traditional vibration processing systems. This hypothesis is tested on a split torque gearbox and results are presented.

Assigned Session: D 1 Wind Turbines

Presenting Author: Junda Zhu **Ser:** 23

Organization: Renewable NRG Systems

Country:

Paper Title: **Development and Validation of Lubrication Oil Particle Contamination Models**

Co Authors: Junda Zhu, Eric Bechhoefer, NRG Systems, Hinesburg, VT 05461, USA

Abstract:

To increase wind energy production rate, there is a pressing need to improve the wind turbine availability and reduce the operational and maintenance costs. The safety and reliability of a functioning wind turbine depend largely on the protective properties of the lubrication oil for its drive train subassemblies such as gearbox and means for lubrication oil condition monitoring and degradation detection. In comparison with current vibration based machine health monitoring, online lubrication oil diagnostic solutions provide over 10 times earlier warning of possible machine failure. The purpose of lubrication oil condition monitoring and degradation detection is to determine whether the oil has deteriorated to such a degree that it no longer fulfills its function. Lubrication oil degradation is classified into three categories: particle contamination, water contamination and oxidation which are defined as three basic degradation features. Over 80% of the machine wear is caused by particle contamination. In this paper, particle contamination of lubrication oil is investigated. Physical models are developed to quantify the relationship between particle contamination level and the output of commercially available online oil dielectric and viscosity sensors. The effectiveness of the developed models is then validated by laboratory experiments.

Assigned Session: D 1 Wind Turbines

Presenting Author: Ruoyu Li **Ser:** 42

Organization: SKF USA RDC

Country:

Paper Title: **Application of Adaptive Filtering in Bearing Fault Detection in Wind Turbine Gear Transmission System**

Co Authors:

Abstract:

Wind turbines are developing and deploying fast as wind power is becoming the world's fastest growing renewable energy source. In the future, reducing the cost of wind power is one of the critical issues with the growth of the wind power. Maintenance of the wind turbine systems is relatively high in the wind business. Condition monitoring of transmission system of the wind turbines could greatly reduce the maintenance cost, avoid transmission system catastrophic failure, and improve the reliability of the whole system. Bearing faults are one of the most common faults in wind turbines and bearings generate relatively weak signals comparing to those of other rotating components of the wind turbine transmission system. Also wind turbine transmission systems work under dynamic operating conditions. Thus develop advanced signal processing methods to effectively extract the bearing faulty information is very important. In this paper, an advanced signal processing method will be applied for bearing fault detection in wind turbine gear transmission systems. The periodic components are removed from the original vibration signal to enhance the bearing faulty signal-to-noise ratio. Both simulation example and real wind turbine vibration signals were used to demonstrate the effectiveness of the presented method. Keywords: Bearing fault diagnosis, Condition monitoring, Wind turbine, Signal processing, Gear transmission system.

Assigned Session: D 1 Wind Turbines

Presenting Author: Eric Bechhoefer **Ser:** 5

Organization: NRG Systems

Country:

Paper Title: **An Enhanced Time Synchronous Averaging for Rotating Equipment Analysis**

Co Authors:

Abstract:

The Time Synchronous Average (TSA) facilitates improved analysis of shaft and gear components on rotating equipment. The TSA, by resampling vibration data synchronously with shaft rotational position, removes the effect of shaft speed variation. Current TSA algorithms use linear or spline interpolation in resampling the vibration data relative to shaft position. This assumes that the derivative of the shaft speed does not change sign (linear) or only changes sign once (spline). This assumption fails to control a 3/revolution change in shaft speed of a wind turbine main shaft (due to tower shadow). Additionally, low rates of the main shaft resulted in excessively long TSA lengths that greatly impact the processing speed and numerical accuracies. This paper presents an enhanced TSA that controls for intra-revolution changes in shaft speed and allows for “in-line” filtering and decimation of vibration data to reduced the length of the TSA.

Assigned Session: D 1 Wind Turbines

Presenting Author: Raja Pulikollu **Ser:** 79

Organization: Sentient Science

Country:

Paper Title: **Advanced Prognostic Health Management Technology for Wind Turbine and Rotorcraft Gearbox Systems**

Co Authors: Nathan Bolander, Raja V. Pulikollu, Adrijan Ribaric

Abstract:

Advanced Prognostic Health Management Technology for Wind Turbine and Rotorcraft Gearbox Systems Nathan Bolander, Raja V. Pulikollu, Adrijan Ribaric Sentient Science Corporation Existing condition monitoring systems can examine the current state of assets, but cannot provide solution for life extension or efficiency improvements. Sentient's solution for wind turbines and rotorcraft industry high maintenance costs and warranty issues is not more monitoring, but a new way to manage maintenance. Sentient developed microstructure-based loads and life prediction models with the goal to accurately estimate fatigue damage initiation and failure in gearbox components. This research lead to the development of a model-based prognostic technology, known as DigitalCloneLiveTM, for use in rotorcraft and wind turbines. The simulation tool considers manufacturing process-microstructure-property relationship, multi-body dynamic effects, gearbox operating conditions, and lubrication effects. DigitalCloneLiveTM technology was successfully used to predict the onset and propagation of surface fatigue and bending fatigue damage in gearbox components. This advanced prognostic and health management technology enables operators to predict maintenance months or years in advance. With this understanding, minor low cost changes can be made to enable long-term benefits to the gearbox systems including improved component life, longer intervals between shutdowns, more efficient maintenance, and diagnostics of faults. The benefits of this technology include safe operation and maintenance at a minimal cost.

Assigned Session: D 1 Wind Turbines

Presenting Author: Joe Murray **Ser:** 88

Organization: Poseidon Systems, LLC

Country:

Paper Title: **Online Wear Debris and Water Contamination Sensing for Wind Turbine Health Monitoring**

Co Authors:

Abstract:

Assigned Session: B 2 Signal Analysis

Presenting Author: Troy Broussard **Ser:** 64

Organization: Cascade Machinery Vibration Solutions

Country:

Paper Title: **Ghost Peak: Collecting the Proper Data to Diagnosis a Problem**

Co Authors: Ivo Dabelic

Abstract:

Cascade was hired to diagnosis a small turbine generator problem on the Big Island of Hawaii. The turbine was not able to get up to the required load of 1MW. The initial data recorded indicated misalignment, but upon further investigation and collecting more specific data, misalignment was ruled out as the cause. A "Ghost Peak" was identified during the many runs during transient data collection. Final diagnosis and root cause was apparent after a fully tops-off visual inspection of the rotating element.

Assigned Session: B 2 Signal Analysis

Presenting Author: Suri Ganeriwala **Ser:** 68

Organization: SpectraQuest Inc

Country:

Paper Title: **Signature Analysis of Cavitation in Centrifugal Pumps**

Co Authors: Surya Kunche

Abstract:

Timely detection of the occurrence of cavitation in pumps is very important as it can cause pitting, erosion, and loss of pump performance. Attempts to determine a unique signature of cavitation using vibration, acoustic emission, audible-acoustics, and higher order non-linear modeling techniques have been elusive. We present the results of an experimental study undertaken first to understand the structure of cavitation and develop an effective means for on-line detection of it. Tests were performed to measure vibration, pressure, sound, motor current and the force due to cavitation of a centrifugal pump. A special force transducer capable of measuring fluctuating forces exerted by cavitation process on the pump casing was developed to understand the dynamics of cavitation phenomenon. Two of the abnormal operating conditions studied were the formation of tiny air bubble (initiation of cavitation) and then fully developed cavitation. Experiments were also run with a transparent LEXAN cover and colored water to observe the cavitation. A Video was also taken for detection. Vibration, force, audible sound, and dynamic pressure were analyzed to detect cavitation. It was found that the pump has higher vibration amplitude in the axial direction than in the radial direction. This may be due to lower stiffness in the axial direction. From the experiments, it was also determined that significant amount of air bubbles will increase vibration component associated with the impeller vane pass frequency. Cavitation might excite high frequency structural resonances. Also, a fully developed cavitation may reduce the impeller vane pass frequency vibration amplitude.

Assigned Session: B 2 Signal Analysis

Presenting Author: Hiroaki Endo **Ser:** 63

Organization: Test Devices Inc

Country:

Paper Title: **An Application of Minimum Entropy Deconvolution Technique in Valve Response Speed Measurement**

Co Authors: Tim Chapman

Abstract:

This paper presents an application of the Minimum Entropy Deconvolution (MED) technique used in enhancing the clarity of impulsive signal resulted from opening and closing of poppet valves. The performance of valves, accuracy and consistency of opening and closing, has significant influence on the overall performance of an air motor driven test rig. Acceleration signals were measured on the valve casing. The impulses resulted from the valve movement, opening and closing, were observed to evaluate the performance of the valve; however the raw signals measured from the valve were masked by significant noise from the flow of compressed air inside the system. The MED filter, tuned to gives the optimum kurtosis level, was used to successfully separate the impulses from the noise and allowed precise assessment of the valve performances.

Assigned Session: B 2 Signal Analysis

Presenting Author: Preston Johnson **Ser:** 38

Organization: National Instruments

Country:

Paper Title: **Order Analysis: An Implementation and Its Use in Vibration Time Waveform Signal Processing**

Co Authors:

Abstract:

Mechanical characteristics of rotating or reciprocating machinery change with speed. To properly capture sensor signals to analyze these characteristics, order analysis is often used. There are several techniques for order analysis and one technique, re-sampling, offers additional advantages for bearing and gearbox degradation analysis. This paper reviews the need for order analysis, two techniques including re-sampling, and advanced analysis using re-sampling based order analysis. Advanced techniques include time synchronous averaging, envelope order spectrum, and zoom order spectrum. Experimental data sets are used to demonstrate the benefits of order analysis techniques.

Assigned Session: B 2 Signal Analysis

Presenting Author: Tony Barlow **Ser:** 62

Organization: Chevron Products Company

Country:

Paper Title: **Acceleration Waveform Analysis: An Advanced Diagnostic Tool in the Detection of Roller Bearing Defect Severity**

Co Authors:

Abstract:

In condition monitoring the detection, identification, and severity assessment of rolling element bearing defects is at the forefront of the discipline of vibration analysis. While many analysts rely solely on spectral data often crucial information contained in the time waveform is overlooked. This paper will focus on the use of the acceleration time waveform and the use of autocorrelation as a means to establish periodicity and approximate bearing defect severity. Presented in this study is the fault progression of a single row deep groove ball bearing as it advances through several stages of defect progression.

This papers focus is intended to serve as an instructional aide; to educate, equip, inform, and challenge the vibration analyst in the advantage of using the acceleration time waveform as an analysis tool in order to properly identify and establish roller bearing defect severity. It is to be remembered, as with any scientific discipline, no single parameter in vibration analysis should ever be used as a panacea in determining the health of rotating equipment. It is the sum of all the diagnostic components that equal the assessment. While this paper centers on one particular aspect or parameter, (i.e. time waveform acceleration) at no time will this case study depart from the above mentioned fundamental hermeneutic in analytical diagnostics.

Assigned Session: B 2 Signal Analysis

Presenting Author: Budhaditya Hazra **Ser:** 80

Organization: University of Waterloo

Country: Canada

Paper Title: **Rotating Machinery Diagnosis Using Synchro-Squeezing Transform Based Feature Analysis**

Co Authors: Sriram Narasimhan

Abstract:

A powerful signal decomposition tool named Synchro-squeezing transform (SST) has recently emerged in the context of non-stationary signal processing. Founded upon the premise of time-frequency (TF) reassignment, its basic objective is to provide a sharper representation of signals in the TF plane. Additionally it can also extract the individual components of a non-stationary multi-component signal, akin to empirical mode decomposition (EMD). The rich mathematical structure based on continuous wavelet transform (CWT) makes SST attractive for rotating machinery diagnosis, through which multiple amplitude-modulated and frequency-modulated signals embedded in noise can be extracted. This work utilizes the decomposing power of synchro-squeezing transform to extract the IMFs from gear and bearing signals, followed by the application of standard rotating machinery condition indicators. This approach promises improved prognostic power than that can be achieved by applying condition indicators directly to the inherently complex data. The efficacy and the robustness of the algorithm are demonstrated with the aid of practical experimental data obtained from a helicopter gearbox test facility in Trenton, New Jersey, and also from seeded bearing fault tests, called the helicopter integrated diagnostic system (HIDS), carried out using an iron bird test stand (SH − 60) at Naval Air Warfare Center (NAWC) - Trenton, and SH−60B/F flight vehicles at NAWC-patuxent river.

Assigned Session: B 2 Signal Analysis

Presenting Author: Wang Zhiyang **Ser:** 21

Organization: Henan Polytechnic University

Country: China

Paper Title: **A Blind Separation Approach of Low Order Cyclostationary Signals**

Co Authors:

Abstract:

Blind source separation (BSS) about cyclostationary signals has a large number of potential applications in many areas from engineering to neuroscience and attracts more and more attention of the researchers over the world recently. This paper presents a new blind separation approach of the cyclostationary signals based on the periodicity of low order cyclostationary signal and it is particularly applicable to the separation of low order cyclostationary signals. The effectiveness of the proposed method is finally demonstrated by computer simulations and experiment.

Assigned Session: C 2 Diagnostic Sensors

Presenting Author: Fred Discenzo **Ser:** 54

Organization: Rockwell Automation, Advanced Technology

Country:

Paper Title: **Optical Torque Sensor Design Enables New Opportunities for Machinery Diagnostics and Failure Prevention**

Co Authors:

Abstract:

Commercial torque transducers are available today and widely used for industrial and commercial applications such as web process lines and vehicle test stands. While currently available sensor provide torque information for process monitoring and control their use is frequently limited to high-value or critical applications due to the cost, size, reliability and performance limitations of commercial torque sensors.

We have previously demonstrated a non-contact optical torque sensor that employs a low cost light source, photo-detector and a photoelastic element. As a polarized light beam is transmitted through the strained photoelastic element the exiting beam exhibits a phase shift in the direction of principal strains and a birefringence pattern appears when viewed through a polarizing filter that is characteristic of the material deformation. When the photoelastic material is attached to a power transmission shaft, this phase shift can be quantified and is directly related to the torsional load on the shaft.

This paper presents the operating principle of the optical torque sensor along with several enhancements that provide for increased accuracy, self-powered operation, and remotely located electronics and active optical elements. These enhancements provide unique opportunities for machinery health assessment and failure prevention

Assigned Session: C 2 Diagnostic Sensors

Presenting Author: Chris Larsen **Ser:** 17

Organization: Etegent Technologies

Country:

Paper Title: **Waveguide Vibration Sensors for Aerospace Health Monitoring**

Co Authors:

Abstract:

Monitoring aerospace components such as turbine engine main bearings or gears which are deeply buried in large transmissions is challenging with current piezoelectric accelerometer technology. Due to the high-temperatures typically involved as well as sensor accessibility, the accelerometer must be mounted on the case, usually far removed from the gear or bearing of interest. Because the sensor is so distant from the vibration source, the defect frequency amplitude is very low and difficult to separate from other vibration sources. A waveguide vibration sensor can be mounted directly inside engines or gearboxes on bearing housings – the vibration passes along the waveguide to the exterior where the piezoelectric sensing element is located. This permits monitoring components very close to the source without placing the sensing element inside the engine or gearbox. Additionally, the long, tortuous vibration transfer path from a bearing to the engine case where a traditional vibration sensor is mounted has a very large dynamic range – any change in speed (or frequency) causes a large change in measured vibration amplitude. However, the waveguide provides for a simple, stable vibration transfer path which simplifies the setting of defect detection thresholds. The waveguide itself can be made of aerospace alloys which are robust to very high temperatures and corrosive environments. While waveguide technology has been used for years for inspection and measurements in hot or inaccessible environments, use of waveguides for vibration measurement is a recent development. Technical challenges which have prevented the use of waveguides for broadband vibration measurement have been met, and demonstration of the technology on a T63 turbine engine with a seeded defect in the thrust bearing shows the waveguide is a revolutionary sensor for aerospace health monitoring.

Assigned Session: C 2 Diagnostic Sensors

Presenting Author: Thomas Connolly **Ser:** 43

Organization: Measurement Specialties, Inc.

Country:

Paper Title: **Unique Inline DC Amplifier with Remote Auto-Zero**

Co Authors:

Abstract:

Transducer applications increasingly demand a greater dynamic range in order to achieve more accurate measurements. Any offset error from the transducer diminishes the amount of gain that can be applied by a pre-amp before clipping occurs at the input to the user's DAQ when DC coupling. In order to address this need, Measurement Specialties is introducing the Model 140 Inline Amplifier that provides high measurement resolution and user-actuated auto-zero in a miniaturized metal package. Typically, a bridge type transducer outputs a low level signal that requires amplification prior to the user's data acquisition system. The effectiveness of this gain stage is often limited by the use of a pre-amp that cannot be located physically close to the transducer. This allows noise to couple along the signal lines prior to amplification which results in a boost in noise along with the signal. Another shortcoming is that any offset error from the transducer diminishes the amount of gain that can be applied by the pre-amp before clipping occurs at the input to the DAQ when DC coupling. A rotary switch recessed into the body of the140 allows a selection of five gain settings from X10 to X200 with an accuracy of 0.5%. The 140 offers a bandwidth from DC to 100 kHz. Noise levels are low with an RTI value of 16 nV /rt-Hz. Auto-zero can be actuated by an on-board pushbutton or remotely by momentarily grounding a designated connector pin through a wire in its detachable mating cable. The auto-zero function has a number of advantages. For one, this provides a zero reference within ±1.5mV of true zero. It also corrects for zero errors due to mounting stresses or misalignment. Lastly, any long term drift errors can be corrected in real time so that the user can zero out the device just prior to taking a measurement. The output of the 140 can be connected single-ended, with a full scale swing up to ±2 volts and a bias of 2.5 Vdc. Or, it can be hooked up pseudo-differentially, using the 2.5 VDC reference voltage provided, as the negative input to the user's DAQ. The 140 is of a rugged design that features an anodized aluminum body with integral threaded circular connectors on either end. Its envelope measures 2.24 inch by 1 inch by 0.5 inch [57mm by 25mm by 13mm] weighing 33 grams. It can be adhesive or screw mounted. It operates over a temperature range of -20°C to +70°C. The user has the choice of powering a transducer with the 5 VDC regulated supply provided by the 140 or passing through power from their own 5 to 30 VDC excitation source, which also powers the 140 signal conditioning circuit. The 140 is ideal for use with differential output transducer applications such as pressure and level indication, static acceleration testing, instrumentation labs, load monitoring, and strain measurement. Additionally, the patent pending technology of the 140 is being incorporated into a new low noise accelerometer Model 4807A with built in auto-zero.

Assigned Session: C 2 Diagnostic Sensors

Presenting Author: David Corelli **Ser:** 73

Organization: IMI Sensors

Country:

Paper Title: **How Sensor Mounting Affects Measurement**

Co Authors:

Abstract:

Sensor mounting can significantly affect both overall vibration and FFT (Fast Fourier Transform) data. This paper describes the differences and confusion in overall measurement techniques and shows how frequency response can affect these measurements. The frequency response of some common mounting methods, such as stud, 2-rail magnet (curved surface), and flat magnet are measured under controlled laboratory conditions and the results presented. The laboratory data is then correlated with actual machinery data. The paper also shows the dramatic effect that mounting has on commonly used high frequency overall measurements such as Spike Energy™ and PeakVue® that are used for early warning of bearing and gear faults.

Assigned Session: C 2 Diagnostic Sensors

Presenting Author: Kevin Westhora **Ser:** 76

Organization: Dytran Instruments Inc

Country:

Paper Title: **USB Powered Triaxial MEMS Vibration Monitoring System Designed for Field Vibration Testing**

Co Authors:

Abstract:

The VibraScout™ vibration measurement system combines a 3-axis MEMS accelerometer with a microcontroller to create an intelligent sensor. Included in the measurement system is a model 7543A USB powered accelerometer, 4-pin to USB cable, and VibraScout™ Software on CD. Features of the device include real-time acquisition and USB transfer of acceleration (including pitch and roll) and temperature data. Units utilize built-in firmware which handles USB communication and provides a number of unique features such as storage of the serial number, storage of accelerometer and temperature calibration data, and addition storage available for customer information such as last cal date, etc. The VibraScout™ Software features real-time logging of data to delimited file (.txt) for easy import into a spreadsheet, and a simple FFT to be able to capture the data in frequency domain. The unique benefit of the VibraScout™ measurement system is that the user is able to easily measure data in the field with the use of the system and a PC.

Assigned Session: B 3 Condition Based Maintenance

Presenting Author: Ted Melencheck **Ser:** 75

Organization: Cargill Deicing Technology

Country:

Paper Title: **Evolution to a World Class PM Facility**

Co Authors:

Abstract:

Maintaining safe reliable equipment is paramount to any organization. This involves getting the maximum uptime at the lowest cost of operation and extending the as designed usable life. The fundamental cornerstone of this proposition is effective lubrication in concert with preventative maintenance and predictive maintenance tasks that are preformed in a quality manner. Each facility has unique challenges to overcome and we all feel like we are doing the best we can for our specific situation. Considering our operation, we started by feeling good that we were cleaning off fill points when servicing equipment in the field. We took oil samples but they only had generic analysis preformed and no actions were taken on the results. Cross contamination of oil was not even given a thought. With training and education our maintenance force became aware that there was a better way. We set aside a designated area to perform servicing and PM's of the equipment. We had oils separated, a filter on the dispensed oil, color coded lube charts by equipment. Oil analysis was preformed and the results drew action. While we felt we were really doing well we also knew we could do better. What if we contained all the necessary lubricants in a box that could be moved as the working areas advanced. The mechanics and apprentices were engaged to assist in designing a world class PM bay. The end result was two containments that housed all lubricants necessary for our mobile equipment fleet with room for expansion. Oil is filtered into and out of storage tanks at 10 micron with beta 1000 filters. All pumping systems are air operated, kidney loop filtration is internal utilizing quick disconnects, waste oil pumping to storage tanks, and work space to complete paperwork. Color coded dispensing nozzles match color coded lubrication charts with all systems and valving labeled and identified. Equipment is positioned on a well lit level cement pad with a wash bay an integral part of the PM bay. While we feel we have a world class facility we are continuously looking for improvements. Currently we are in the process of installing wireless lubricant usage tracking by asset.

Assigned Session: B 3 Condition Based Maintenance

Presenting Author: Michael Lipsett **Ser:** 40

Organization: University of Alberta

Country: Canada

Paper Title: **Anomaly Detection in a Two-Tank System Using an Interacting, Multiple-Model-Based Fault Detection Method**

Co Authors: Amanda Kotchon

Abstract:

This paper presents a method of fault detection and identification (FDI) for nonlinear system that is constructed based on the interacting multiple model (IMM) algorithm. The fault diagnostic approach is formulated as a hybrid multiple model estimation scheme. The proposed approach provides an integrated framework for fault detection, diagnosis, and state estimation. The proposed method can be used with different kind of filters like linear Kalman filter, extended Kalman filter, unscented Kalman filter and particle filter with respect to the application. Its performance is illustrated for fault detection of a nonlinear two-tank system. A set of models is assumed to present the possible system behavior pattern or modes and they run in parallel as a bank of filters. Different filter is used for testing and comparing the performance fairly. Performance comparisons are made between filters using the confusion matrix and classification accuracy.

Assigned Session: B 3 Condition Based Maintenance

Presenting Author: Paula Dempsey **Ser:** 70

Organization: NASA Glenn Research Center

Country:

Paper Title: **Validation of Helicopter Gear Condition Indicators Using Seeded Fault Tests**

Co Authors: E. Bruce Brandon US Army, Redstone Arsenal, Al

Abstract:

Helicopter transmission integrity is important to helicopter safety because helicopters depend on the power train for propulsion, lift, and flight maneuvering. Health Usage Monitoring Systems (HUMS) capable of predicting impending equipment failure for “on-condition” maintenance have the potential to decrease operating and maintenance costs and increase safety and aircraft availability. These “condition indicators” (CI) are typically vibration signatures that develop when damage occurs on a component. Tests of components in test rigs are often used for validation of CIs prior to their use on the helicopter. This is due to the time and expense required to collect a statistically significant set of failure progression data in a full-scale helicopter gearbox and the limited aircraft data available on damaged components. In many cases, the CIs perform differently when taken from a component test stand or even a full-scale transmission test stand and implemented on the aircraft. If data collected from a test rig is to be used to validate a CIs performance we must show its performance can be maintained when installed on the aircraft. A methodology must be defined that outlines the steps that verify condition indicator performance in the lab can be maintained at a comparable level of performance when monitored on the aircraft. The objective of this paper is to step through all of the processes required when using lab fault tests to demonstrate CI performance in the field. This paper focuses on the methodology required. If seeded fault tests are used to measure the performance of condition indicators, the tests must be verified as representative of flight data. Problems encountered or lessons learned when transferring the diagnostic tool from the lab to the helicopter due to system constraints will also be discussed. The process will also be mapped to the steps defined within the US Army Aeronautical Design Standard Handbook that provide guidance for the development and performance of component seeded fault testing programs. In order to demonstrate the process needed to validate lab CI performance, four CI component data sets are required from a healthy helicopter, faulted helicopter component, healthy test stand and faulted test stand. The platform/component/fault type was targeted for this analysis based on availability of fleet flight data, tear down analysis, operational data and maintenance records. The targeted components are spiral bevel gears. Gear CI data from an AH64 nose gearbox when damage occurred will be compared to data generated in a spiral bevel gear fatigue rig. The paper will outline the analysis and tests required to compare both systems. The scope of this paper is limited to the methodology employed to compare the two systems to define the limitations and constraints.

Assigned Session: B 3 Condition Based Maintenance

Presenting Author: Mike Behm **Ser:** 55

Organization: Behm Balancing Devices

Country:

Paper Title: **Expert System for Condition Based Maintenance**

Co Authors:

Abstract:

Electronic vibration analyzers have been in use since the 1960's. However they only collect vibrational data (amplitude, frequency and phase) and the trained technician performs the actual vibration analysis. Various machinery faults can be identified by the technician, based on this information. Single plane and dynamic balancing can also be performed using these instruments by those trained in the art. Laptop computers taken to the job site can be programmed using data bases such as Microsoft Excel to identify these machinery faults; such as resonance, bad antifriction bearings, unbalance, etc.. Furthermore, normal running rotating machinery can provide baseline data to create a Condition Based maintenance system running on a laptop computer. The mathematics used for balancing can also be programmed to run on these computers. Simply put, all the techniques used by trained vibration analysis technicians can be programmed into portable computers. These types of programs are commonly referred to as Expert Systems.

Assigned Session: C 3 Wireless Sensors

Presenting Author: Aaron Schiele **Ser:** 3

Organization: National Instruments

Country:

Paper Title: **Wireless Technologies and Application to Condition Monitoring Systems**

Co Authors: Doug Farrell, Jim Schwartz

Abstract:

Today's wireless spectrum is abundant in a variety of standards used to remotely acquire and transmit data, making it difficult to choose the right standard for the condition monitoring application. This paper reviews the most common wireless technologies used in data acquisition and transmission including Wi-Fi, Cellular, Mesh Networks, Long Range Radios, and Satellite. The goal of the paper is to provide the reader enough information to choose the technology for specific applications.

Assigned Session: C 3 Wireless Sensors

Presenting Author: Lei Zuo **Ser:** 53

Organization: State University of New York at Stony Brook

Country:

Paper Title: **A Piezoelectric Multilayer-Stack Energy Harvester with Force Amplification for Damage Detection Sensors**

Co Authors: Wanlu Zhou Tianbing Xu (National Institute of Aerospace, Hampton, VA 23666)

Abstract:

A piezoelectric lead zirconate titanate (PZT) multilayer-stack flextensional energy harvester (PZT-Stack-FEH) for damage detection sensors was designed and characterized in this paper. The power harvested from ambient vibration in the environment is utilized for the power supply of the damage detection sensor. An elastic flextensional frame for force amplification was optimally designed to transmit more mechanical energy with high efficiency to the PZT-Stack-FEH. Instead of 31-mode single layer piezoelectric component, a 33-mode piezoelectric PZT multilayer stack was employed to increase mechanical-to-electrical energy conversion efficiency. Theoretical analysis and experiments were carried out. The experiment results show that the mechanical-to-electrical energy conversion efficiency of the PZT-Stack-FEH is 19%, 48.6 times more mechanical energy can be transmitted to PZT-Stack-FEH, and 26.5 times more electrical energy can be generated by using the PZT-Stack-FEH than directly applying force to the PZT multilayer stack. The power generation performance of the PZT-Stack-FEH with a proof mass was also studied. Experiment results show that he peak power/acceleration can attain 2400mW/g when the PZT-Stack-FEH is connected with a proof mass of 200 grams and 3280 mW/g with a proof mass of 500 grams.

Assigned Session: E 3 Data Analysis

Presenting Author: Charles Dibsdale **Ser:** 22

Organization: Optimized Systems and Solutions

Country: United Kingdom

Paper Title: **Knowledge Management and Predictive Maintenance**

Co Authors:

Abstract:

Predictive maintenance is a knowledge intensive discipline. The requirements for knowing how assets are put to work in different markets, who the stakeholders are and what they expect from the assets, and how the assets behave in their various operating contexts all drive the funcdamental requirements of what we want a predictive maintenance regime to deliver and how it adds value. The subject of this paper is to outline the predictive maintenance context that drives the need for this aspect of knowledge management and then discuss a means by which it may be captured collated disseminated and re-used. The paper will cover how traditional tools may be re-used, such as a FMEA, but how these tools need to be extended to cater for the needs of defining a predictive maintenance regime, including some of their shortfalls and disadvantages. Whilst the focus will be on explicit knowledge (the type of knowledge which may be recorded and rationalised) we will also touch on Tacit knowledge (That which cannot be recorded or consciously rationalised) and what part that plays in a predictive maintenance regime and how this aspect of knowledge must be managed differently.

Assigned Session: E 3 Data Analysis

Presenting Author: Fred Discenzo **Ser:** 29

Organization: Rockwell Automation, Advanced Technology

Country:

Paper Title: **Accelerated Diagnostics & Prognostics Development Using Common Data Libraries**

Co Authors: Kenneth A. Loparo Professor Case Western Reserve University kal4@case.edu

Abstract:

Machinery failure prevention using advanced diagnostic and prognostic algorithms is a topic of high interest for many organizations responsible for the operation of manufacturing, military, and commercial systems. New, more capable algorithms are reported almost weekly along with an assessment of their enhanced performance. The use of common data libraries can provide important benefits for the development, validation, evaluation, and deployment of new algorithms. Algorithm developers often lack laboratory testing resources to conduct the experiments needed to capture large amounts of data to thoroughly validate their results. As a result developers are frequently forced to use available data that may not adequately represent the fault types of interest or may be incomplete or cover a limited number of test cases, or may not be well documented regarding the fault types and data acquisition details. Alternatively, many algorithm developers may use only synthetic or simulation data to validate and describe the algorithm performance. Understanding the specifics of the data used for algorithm validation is frequently needed in order to understand algorithms true capabilities. Using a common, readily accessible set of existing machinery data captured under known conditions that span a wide range of fault types and fault severity levels can often eliminate the need for the developer to design, build and conduct laboratory experiments or to develop models and conduct simulation studies. Furthermore, the evaluation of different algorithms is facilitated by using common data files captured under known, rigorous test conditions. A set of publicly available motor test data has been in use for over 10 years to provide developers a rich set of test data captured under documented laboratory test conditions. This data was captured as part of a program conducted by Case Western Reserve University and Rockwell Automation is directed at the detection of incipient bearing failures. This work, supported by the Office of Naval Research, has resulted in a publically available suite of bearing fault vibration data files. The test conditions include seeded faults along with a description of the fault and details of the data acquisition system and sensors used. This library of data files has assisted many developers in evaluating new algorithms and reporting the benefits provided. It also provides a common frame of reference when evaluating different diagnostic and prognostic methods. This paper will describe the scope of the public data files and how they may be used. Details regarding the fault types and data acquisition system will also be provided. Examples will be presented showing how many developers have benefited from this public library will be presented. Instruction will be given on how to access and use the library data files. Other publicly available diagnostic data fields will be presented along with a framework to establish a cloud-based library system for machinery diagnostic development. The ready access to a rich set of data captured under well-documented rigorous test conditions promises to accelerate the development and deployment of next generation of algorithms for machinery failure prevention.

Assigned Session: E 3 Data Analysis

Presenting Author: Preston Johnson **Ser:** 37

Organization: National Instruments

Country:

Paper Title: **Big Data: Analog Sensors Flood Asset Monitoring Systems, Data Mining and Data Reduction Tools**

Co Authors:

Abstract:

With lower cost data collection systems, improved connectivity of control sensors, and a more pervasive plant networking system, more data is flowing into the asset monitoring systems than before. Data management and mining tools are needed at all levels in the data flow process. Tools include data reduction scoring techniques within the data collection devices, data conversion tools to transform data collection devices from a variety of vendors, in-line analytics as data moves from device to the first computer on the network and to the broader IT network. Once at rest, there are several popular data mining platforms available to fuse high value data into a diagnostic and prognostic advisory system. This paper reviews techniques used at the data collection level, at the first plant node computer level, and within the back end IT system. A pilot case study is presented using a commercial big data platform.

Assigned Session: E 3 Data Analysis

Presenting Author: Harlan Shober **Ser:** 89

Organization: RJ Lee Group Inc

Country:

Paper Title: **Big Data Search of Engineering Test Data**

Co Authors:

Abstract:

Assigned Session: E 3 Data Analysis

Presenting Author: Mohamed AbuAli **Ser:** 87

Organization: FORCAM

Country:

Paper Title: **Big Data Analytics in Manufacturing**

Co Authors:

Abstract:

Assigned Session: B 4 Prognostics

Presenting Author: Shane Clarkson **Ser:** 9

Organization: Expert Microsystems, Inc.

Country:

Paper Title: **Path Classification and Remaining Life Estimation for Systems Having Complex Modes of Failure**

Co Authors: Randy Bickford rbickford@expmicrosys.com

Abstract:

Prognostic health management for complex systems is receiving increasing attention, with an emphasis on techniques for remaining useful life estimation. A novel Path Classification and Estimation (PACE) technique is described for estimating remaining useful life for systems and components experiencing complex and possibly competing failure modes. The remaining useful life of a sample of aging aircraft turbofan engines is predicted by classifying each engine's degradation path in reference to degradation path models calibrated with actual run-to-failure data for similar engines. The degradation path model inputs are derived from pattern recognition models of the normal behavior for these engines. Deviations between the expected signal values and the model estimated values are evaluated to determine when a monitored engine is degrading excessively and to classify the engine's degradation path in reference to similar end-of-life paths. Remaining useful life is estimated based on the path classification. The results illustrate the evolution of the remaining life estimate from the point where the degradation trend is first detected to the point of actual failure for a sample of engines. The results show that the PACE technique is a fast, accurate, and online capable method providing data-driven remaining useful life estimation for complex systems having multiple failure modes that might occur individually or in combination.

Assigned Session: B 4 Prognostics

Presenting Author: Preston Johnson **Ser:** 16

Organization: National Instruments

Country:

Paper Title: **Fleet Wide Asset Monitoring: Sensory Data to Signal Processing to Prognostics**

Co Authors:

Abstract:

Next generation fleet wide asset monitoring solutions are incorporating machine failure prediction and prognostics technologies. These technologies build on signal processing of vibration time waveforms, process parameters, and operating conditions of the machine. For prognostics algorithms to work well, the signal processing algorithms need to be applied correctly and the results need to be reliable. This paper provides a survey of signal processing techniques as applied to specific machine component with a focus on the output and use with prognostics technologies. With properly organized outputs, prognostics algorithms transform the fleet condition and health management challenge into a deployable fleet health management solution. To arrive at the deployable fleet management solution, a systematic approach in the design of the prognostics system is preferable. This approach includes data and model driven failure patterns, sensory data connectivity from deployed assets, prognostics analytical applications, and advisory generation outputs which guide the asset owners and maintainers. To illustrate the concepts, a fleet wide power generation asset monitoring case study is presented.

Assigned Session: B 4 Prognostics

Presenting Author: Jordan McBain **Ser:** 74

Organization: LHP Software, LLC

Country:

Paper Title: **Condition Monitoring of Non-Linear Time Varying Systems: Gearboxes Subject to Varying Load and Speed**

Co Authors:

Abstract:

There are many systems in industry that are run under time-varying conditions. Structures are subject to varying temperatures; hydraulics are subject to varying flows, temperatures and pressures; engine after-treatment systems are subject to varying temperatures, mass flow, and gas concentrations. Diagnostics and prognostics for these systems can be very challenging given their complex time-varying non linearities. This presentation will detail techniques developed to handle this class of problem with high-quality results achieved from vibration data gathered from a gear dynamics simulator run under varying load and speed. A combination of system identification or cross-correlation of a system's input/output signals along with support-vector-based novelty detection are shown to be largely insensitive to the challenging aspects of gear and bearing diagnostics under these conditions. Thoughts on the extension of these techniques to prognostics are presented.

Assigned Session: B 4 Prognostics

Presenting Author: Jean-Baptiste Leger **Ser:** 72

Organization: PREDICT & DIAG 21

Country: France

Paper Title: **Predictive Diagnostic Based on a Fleet-wide Ontology Approach**

Co Authors: Gabriela Medina-Oliva, Jean-Baptiste Leger, Alexandre Voisin, Maxime Monnin

Abstract:

In order to anticipate failures and reduce downtime, “predictive diagnosis” aims not only at early warning about failure events before they occur but also at identifying the causes of degradation leading to such detections. However, this is a complex task since the maintenance operators/engineers needs to analyze the alarm and the symptom behavior/evolution to understand which components may have caused the symptom to appear and the reasons for the abnormal behavior of the system. Moreover, engineers need to analyze the operational context of the failure in order to understand the abnormal situation since it influences the system behavior. To tackle this issue, a Prognostics and Health Management (PHM) approach enables to dispose of both real-time and historic data coming from components. However in many industrial domains, component and equipment standardization for costs reduction design, logistics, etc. allows considering a fleet-wide approach. According to PHM and more specifically for predictive diagnosis activities, this kind of approach allows to gather data and/or information related to all the fleet systems on the same benchmark in order to bring out more relevant results. This way, a fleet-wide approach enables engineers to retrieve historic events occurred all over a fleet of systems to compare potential similar events and investigate them in order to complete/extract valuable information for the resolution of the current/on line abnormal situation.

In order to achieve PHM at a fleet level, it is thus necessary to manage relevant knowledge arising from both modeling and monitoring of the fleet to take into account heterogeneities and similarities amongst components, operational contexts, behaviors, etc.

This paper presents a knowledge structuring scheme of fleets based on ontologies for diagnostic purposes oriented to the marine domain. The added-value of this approach consists on structuring knowledge arising from a fleet in order to capitalize knowledge and to retrieve knowledge/data on past events among the fleet to facilitate diagnosis tasks. In that sense, it enables relevant data about similar systems to be retrieved, to isolate the alarm and to make hypothesis based on real historical cases about the causes producing it.

This original approach is supported by the KASEM® (Knowledge and Advanced Service for E-Monitoring) e-maintenance software platform. Based on an open Service Oriented Architecture (SOA) foundation. KASEM® delivers a “hub of technologies” in an interoperable and integrated framework for fleet-wide PHM. Including a workflow for problem solving process, it allows analysis follow-up and decision tracking for knowledge capitalization.

The added-value of this knowledge-based system, mainly in terms of knowledge structuring and reasoning, is shown on a predictive diagnostic case studies and situations concerning diesel marine engines for propulsion and for power-plant. The fleet is composed of 17 heterogeneous diesel engines, produced by 4 manufacturers and includes 9 manufacturer references, number of cylinders from 6 to 16, configurations in line or in V and 2 or 4-stroke cycles engines.

Key words: Fleet-wide management, proactive maintenance, ontologies, knowledge capitalization, predictive diagnostic.

Assigned Session: B 4 Prognostics

Presenting Author: Shiyu Zhou **Ser:** 78

Organization: University of Wisconsin-Madison

Country:

Paper Title: **Remaining Useful Life Prediction of Individual Units Subject to Hard Failure**

Co Authors: Qiang Zhou Xiaofeng Mao, General Motor R&D Center Mutasim Salman, General Motor R&D Center

Abstract:

To develop a cost-effective condition-based maintenance strategy, accurate prediction of remaining useful life (RUL) is the key. As many failure mechanisms in engineering can be traced back to some underlying degradation processes, we propose a two-stage prognostic framework for individual units subject to hard failure, based on joint modeling of degradation signal and time-to-event data. The proposed algorithm features online prediction and dynamic updating. Its application to automotive battery residual life prediction has been discussed in this paper as an example. The effectiveness of the proposed method has been demonstrated through both simulation study and real data.

Assigned Session: C 4 Failure Analysis

Presenting Author: Skip Morrison **Ser:** 44

Organization: PROGNOST Systems, Inc

Country:

Paper Title: **Is Frame Vibration Monitoring Enough to Mitigate the Risk of Loss of Mechanical Integrity for Reciprocating Compressors?**

Co Authors: Rob van Ijzendoorn, BP

Abstract:

In March 2009, a new 4-throw reciprocating compressor in refining hydrogen service was being commissioned in Rotterdam, The Netherlands. Twenty hours into the first gas load run, the compressor was switched to 50% load step by activating head end plug unloaders. Until that time all frame velocity, crosshead acceleration and piston rod run out measurements were all within normal limits. Eight minutes later, ta SIL2 certified machinery protection system shut down the compressor on high crosshead acceleration before any significant increase in frame velocity was measured. Inspection of first stage crosshead showed blue coloration of seized wrist pin and small end of connecting rod due to lack of lubrication. Disassembly of crosshead revealed total absence of babbitt material on leading edges of lower shoe indicating running crosshead was being tilted in guide when free rotation of wrist pin in sleeve bearing ceased with loss of lubrication. Analysis of combined gas and inertial rod load curves showed reversal period was well above minimum API standard. While the data analysis showed nearly no increase in frame vibration amplitude anytime during the event, within 2 minutes of load step change, crosshead vibration increased steadily until default shut down limits in the 6 g range were reached approximately 6 minutes later. An increase in vertical displacement of the piston rod was also clearly evident even before the increase in crosshead vibration. This case study will illustrate the advantages available to reciprocating compressor operators in successfully avoiding severe consequential damages through the use of proven crosshead vibration and rod run out safety shut down techniques. It also played a major role convincing the API-618 and 670 task force to include crosshead acceleration as a recommended trip point in the new editions of both standards.

Assigned Session: C 4 Failure Analysis

Presenting Author: Keith Wagner **Ser:** 36

Organization: RJ Lee Group

Country:

Paper Title: **The Impact of Dynamic Loading on Root Cause Failure Analysis**

Co Authors: Keith Wagner

Abstract:

Advances in materials science have made many engineering advances possible, particularly in aviation and aeronautics. The complexities of operation and the severe service environments have required multiple generations of engineered materials and alloys with specific properties to achieve the desired performance. Depending on the industry and application, significant engineering efforts are made in material development to create the “ideal” material, or textbooks are consulted to find an existing material with the right properties. In either case, mechanical property data under standard conditions (temperature, strain rate, etc.) are the easiest to find because they are the easiest to measure. However, dynamic loading can result in unanticipated material behavior and failure modes that would not be operative under static conditions. This can be driven by high strain rates caused by impact shock waves, or complex loading caused by rapidly variable interactions between the material and its environment. In some cases the dynamic performance of the material is a focus in product design while in others it is not considered. Regardless, material strain rate sensitivity is an important consideration during a failure investigation and may be vital evidence in determine the root cause. The focus of this presentation will be the effect of dynamic loading on materials performance in engineering applications. The major focus will be a case study involving aircraft landing gear and the importance of strain rate sensitivity in materials selection for this application. Other examples of material behavior under dynamic loads will be presented and contrasted with performance under static conditions, including applications in which such loads might not be expected. In particular, the failure of a buried natural gas line will be discussed as will the mechanical response of solder in circuitry under high strain rates.

Assigned Session: C 4 Failure Analysis

Presenting Author: Todd Letcher **Ser:** 39

Organization: South Dakota State University

Country:

Paper Title: **Geometric Sensitivity Analysis and Improved Empirical Observation for Reduced-Order Fatigue Life Assessment**

Co Authors: Onome Scott-Emuakpor (2), Tommy George (2), Casey Holycross (2,3) (2) - Air Force Research Laboratory, Wright-Patterson AFB (3) - The Ohio State University, Columbus OH

Abstract:

A reduced-order fatigue life assessment uses a physics based model to characterize fatigue behavior quicker and more cost effective than traditional experimental means. Most of these models are constructed with support from the physics behind axial fatigue testing of simple/standard dogbone specimens. Though these methods have shown promise in predicting fatigue behavior of a few alloys, transitioning from assessing failure behavior of standard dogbone specimens to real world components is of interest to design engineers, particularly those in industries where fatigue failure could result in catastrophic events – i.e. gas turbine engine industry. As a first step to make this transition to real world parts, this paper examines the axial fatigue life behavior of standard dogbone specimens with different sizes and geometries for Aluminum (Al) 6061-T6 and Titanium (Ti) 6Al-4V. These fatigue results are observed alongside an existing reduced-order fatigue lifing model called the energy-based fatigue life prediction method. This observation is conducted in order to determine if the effects of size and geometry should be incorporated into the lifing model. In addition, a different reduced-order fatigue life assessment approach is introduced, and it follows the same energy-based method theory. The new approach involves short duration fatigue testing at a few different stress amplitude levels on a single specimen, and then the stress amplitude versus fatigue life cycle behavior is determined using the failure/energy correlation. With the observation of this new fatigue life assessment method, a new way of validating the appropriateness of the prediction is also explore. Though the results in the manuscript are refutable, they provide encouragement to continue the research on an accelerated fatigue life behavior assessment methods and a validation process for proving the appropriateness of a reduced-order fatigue life model.

Assigned Session: C 4 Failure Analysis

Presenting Author: Ibraheem Sabry **Ser:** 15

Organization: Middle Delta Electricity Production Company, Material

Country: Egypt

Paper Title: **The Joint Properties for Friction Stir Welding of Aluminum Tubes**

Co Authors: A.M. Khourshid, Prof. Dr. Production Eng., Faculty of Eng., Tanta University, ARE

Abstract:

Friction Stir Welding (FSW), a solid state joining technique, is widely being used for joining Al alloys for aerospace, marine automotive and many other applications of commercial importance. FSW were carried out using a vertical milling machine on Al 5083 alloy pipe. These pipe sections are relatively small in diameter, 5mm, and relatively thin walled, 2mm. .In this study, 5083 aluminum alloy pipe were welded as similar alloy joints using (FSW) process in order to investigate mechanical and microstructural properties .rotation speed 1400 r.p.m and weld speed 10,40,70 mm/min. In order to investigate the effect of welding speeds on mechanical properties, metallographic and mechanical tests were carried out on the welded areas. Vickers hardness profile and tensile tests of the joints as a metallurgical investigation, Optic Microscopy and Scanning Electron Microscopy (SEM) were used for base and weld zones.

Key words: friction stir welding (FSW), Al alloys, mechanical properties, microstructure

Assigned Session: D 4 Systems Engineering and Business Case Analysis

Presenting Author: Chris Pomfret **Ser:** 81

Organization: MFPT Society

Country:

Paper Title: **Methods to Derive Business Case Analyses**

Co Authors:

Abstract:

Assigned Session: D 4 Systems Engineering and Business Case Analysis

Presenting Author: Alex Braafladt **Ser:** 51

Organization: University of Minnesota

Country:

Paper Title: **Investigation of Materials for Boundary Layer Control in a Supersonic Wind Tunnel**

Co Authors: Alexander Braafladt, University of Minnesota Twin Cities
John M Lucero NASA Glenn Research Center
Stephanie M Hirt, NASA Glenn Research Center

Abstract:

During operation of the NASA Glenn 15 by 15 centimeter supersonic wind tunnel (SWT), a significant, undesirable corner flow separation is created by the three-dimensional interaction of the wall and floor boundary layers in the tunnel corners. A method to minimize this effect was conceived by connecting the wall and floor boundary layers with a radius of curvature in the corners. The results and observations of a trade study to determine the effectiveness of candidate materials for creating the radius of curvature in the SWT are presented. The experiments in the study focus on the formation of corner fillets of four different radii of curvature, 0.25 inches, 0.375 inches, 0.5 inches, and 0.625 inches, based on the observed boundary layer thickness of 0.45 inches. The experiments were performed on ten candidate materials determining shrinkage, surface roughness, cure time, ease of application and removal, adhesion, eccentricity, formability, and repeatability. Of the ten materials, those exhibiting characteristics most promising for effective use were tested in the 15 by 15 cm SWT. Of these, the particular material which was most effective, as described below, was chosen for use creating the corner fillets in the upcoming experiments on shock-wave/boundary-layer interaction.

Assigned Session: D 4 Systems Engineering and Business Case Analysis

Presenting Author: Jim Lauffer **Ser:** 41

Organization: DSI International, Inc

Country:

Paper Title: **Critical Prognostics Design Balance within the Integrated Systems Diagnostics Design (ISDD)**

Co Authors:

Abstract:

Much effort has been made in the prediction of failures prior to occurrence. The fundamental theory behind this failure prediction is paramount to preventing critical system failures, where possible and practical. While much has been published on this subject, as well as practical demonstrations, important issues remain: 1) what is the confidence for Remaining Useful Life (RUL)? 2) what prognostic information can be observed, and understood, at the system Health Management level? And 3) what is the impact on maintenance actions, cost, and Availability? With the preponderance of prognostic working groups, studies, and concept developments, much information on prognostics technology has been developed. A point here is, prognostics in this sense is advanced physics of failure driven CBM and not RCM based trend analysis. The latter is of little value in deriving RUL with any confidence. The question that is always lingering behind the theory is, how do we know the optimum candidates have been selected for prognostic testing? This question can now be added to previous three questions. The answer is effective prognostics cannot exist on its own; it must be a subset of a systems engineering process! To have a truly effective system Health Management (not monitoring) design, a well-balanced and integrated diagnostics and prognostics based solution must be developed. Other factors are obviously needed for this balance and they will be discussed in the paper. This paper is focused on the critical balance of the factors required to produce a Health Management System that meets technology as well as business case objectives. The core of this balanced solution is the Integrated System Diagnostics Design (ISDD). ISDD initially includes prognostics requirements along with other factors in the diagnostics analysis. As the design matures and candidates are analyzed, actual prognostic parameters will replace the initial requirement inputs. The major point of the paper is to show why the prognostic candidates must be derived from the diagnostics analysis to endure an effective and well balanced Health Management solution. This paper will also show the impact of prognostics, both positive and negative, on the systems maintenance, operational integrity, and sustainment impact with cost and Availability.

Assigned Session: D 4 Systems Engineering and Business Case Analysis

Presenting Author: James Winkel **Ser:** 60

Organization: NASA

Country:

Paper Title: **ANCFII-Test Rig Support Bearing Trade Study**

Co Authors:

Abstract:

Since 1995 the Advanced Noise Control Fan (ANCF) has significantly contributed to the advancement of understanding of the physics of fan tonal noise generation. The Low Speed/ Loading/ Pressure nature of ANCF is not representative of full scale models in the physics of fan broadband noise generation and is considered a low Technology Readiness Level 3 effort. For higher TRL 5, the high cost of running the 9x15 foot Wind Tunnel (WT) limits testing to single point designs preventing the parametric investigations required for detailed understanding of the physics necessary for successful technology development. As a result of this limitation a new Fan Test Rig is required to bridge from TRL 3 to 5, thus enabling the successful completion of NASA/Industry noise reduction program goals. The new test rig, ANCF II, will match the flow and loading characteristics of the 9x15 Wind Tunnel scale models. These designs will be directly transferable to the 9x15 WT which will greatly lower the development risks. The purpose of the bearing conceptual study for ANCFII is to identify existing bearing technologies to meet the program driving requirements and develop a robust test rig design. Due to limitations of conventional bearing designs, six feasible core bearing technologies have been identified for this application. The technology screening process and subsequent trade study to select the most feasible concept is described in this presentation.

Assigned Session: D 4 Systems Engineering and Business Case Analysis

Presenting Author: John Lucero **Ser:** 61

Organization: NASA John H Glenn Research Center

Country:

Paper Title: **ANCFII Risk Analysis**

Co Authors:

Abstract:

Assigned Session: D 4 Systems Engineering and Business Case Analysis

Presenting Author: Fatih Cebeci **Ser:** 52

Organization: Turkish War Colleges

Country: Turkey

Paper Title: **Implementation of Performance-Based Acquisition in Non-Western Countries**

Co Authors:

Abstract:

"Performance-based acquisition (PBA)" means an acquisition structured around the results to be achieved as opposed to the manner by which the work is to be performed. Performance-based acquisition is a results-oriented acquisition strategy used to achieve innovative solutions in agency programs. Most military systems have been used for decades, so future planning of defense procurement is critically important. Performance-based acquisition is a strategic method to manage business by promoting flexibility and innovation and creating win/win solutions through effective communication, organizational goal alignment, and clear accountability among the buyer, seller(s), and subcontractors. In this century, many governments are transitioning their acquisition strategy from traditional methods to performance-based methods. In 2000, the U.S. Department of Defense set a goal that a minimum of 50% of the service acquisitions would use performance-based acquisition methods by 2005. Similar to the US DoD policy many defense departments around the world have been in search of new methods to reduce the defense spendings and increase warfighter capability. In this point of search Performance Based Acquisition emerge to be the most effective method. Do cultural differences have significant importance to the success of this new acquisition method? Applying PBA methods in Western countries have shown successful results. What results can be obtained from applying this new strategy in other countries around the world? This article focuses on the implementation of performance-based logistics and search the success of PBA in different countries.

Assigned Session: B 5 Applications of Health Management Technologies

Presenting Author: Keith Calhoun **Ser:** 83

Organization: Rolls-Royce Corp.

Country:

Paper Title: **Rolls-Royce EHM Successes**

Co Authors:

Abstract:

Assigned Session: B 5 Applications of Health Management Technologies

Presenting Author: Wade Clark **Ser:** 85

Organization: The GBS Group

Country:

Paper Title: **Applied Case Study in Information Fusion and Health Management for High Speed Trains**

Co Authors:

Abstract:

Assigned Session: B 5 Applications of Health Management Technologies

Presenting Author: Mark Lochhaas **Ser:** 86

Organization: Advantech Corporation

Country:

Paper Title: **Collecting and Concentrating Automation Data**

Co Authors:

Abstract:

Assigned Session: C 5 Failure Prevention

Presenting Author: Patrick Kilbane **Ser:** 50

Organization: ALS | Tribology

Country:

Paper Title: **How Information Makes All the Difference in Oil Analysis**

Co Authors:

Abstract:

This presentation will discuss the information need to make accurate diagnosis of oil analysis reports. We will look at several examples of where the information or lack thereof makes a difference in how the customer and laboratory perceive the analysis and data. Oil Analysis like many of the condition monitoring techniques is dependent on the location of the sample. We will discuss sampling locations and proper sampling methods to provide the best possible information.

Assigned Session: C 5 Failure Prevention

Presenting Author: Robert Veale **Ser:** 56

Organization: Rockwell Automation

Country:

Paper Title: **The Effects of Airborne Contamination on Industrial Control Electronics**

Co Authors:

Abstract:

Environmentally induced failures of industrial electronics have been a recurring problem over many years. Within most industrial settings these failures can be very costly if processes are interrupted. A variety of atmospheric pollutants can lead to premature equipment failure including airborne particulates and gases. As electronic controls are installed in closer proximity to industrial processes there is an increased risk for airborne contaminants to affect electronic circuitry. Also, control electronics is increasingly being utilized in the developing world where there may be less awareness of how harsh environments can affect electronic systems.

This paper will describe common failure modes caused by atmospheric pollutants. A method for assessing a site for the risk of corrosion failures will be presented along with a discussion of risk mitigation methods.

Assigned Session: C 5 Failure Prevention

Presenting Author: Ben Laskowski **Ser:** 48

Organization: Analatom

Country:

Paper Title: **Corrosion Detection on Natural Gas Pipelines with Micro-Linear Polarization Resistance Sensors**

Co Authors: Richard Connolly, Duane Darr, Jefferey Morse, Bernard Laskowski

Abstract:

This paper presents an experiment adapting linear polarization resistance-based corrosion sensors, developed originally for aerospace applications, to measure the corrosion rate of API 5L ERW grade-B steel natural gas line pipe using micro-sized linear polarization resistance (LPR) sensors made from the same alloy and grade steel. Sensors were installed under a 15 mil coating of fusion bonded epoxy, at various proximities to a 1/8 inch defect introduced at a weld joint and along the pipe seam. After sensor installation the pipe was buried in an controlled environment with soil amended to a pH of five. This environment was held at a temperature above 35°C while soil moisture content was modulated between wet and dry cycles, each lasting seven days. LPR and environmental measurements were sampled at five minute intervals. Post processing was performed to convert the LPR measurements to a mass-loss using the presented algorithms. Comparisons made in the data showed API 5L ERW grade-B steel natural gas pipelines were highly susceptible to corrosion along the seam, with all sensors showing activity in this region early in the experiment. Sensors adjacent to a weld joint began to display evidence of corrosion more slowly. These results verify the ability of µLPR sensors to measure corrosion activity under protective coatings in underground environments.

Assigned Session: C 5 Failure Prevention

Presenting Author: Marc Pepi **Ser:** 18

Organization: US Army Research Laboratory

Country:

Paper Title: **Cold Spray Technology as a Repair Technique**

Co Authors: Victor Champagne

Abstract:

The U. S. Army has experienced significant corrosion problems with magnesium alloys that are used to fabricate aircraft components. Many of these high-value rotorcraft components have to be removed prematurely because of degradation. Many of the parts cannot be reclaimed because there was not an existing technology that could restore them adequately for service. The U.S. Army Research Laboratory has developed a cold spray process to reclaim magnesium components that shows significant improvement over existing methods. This program resulted in the validation of a Cold Spray (supersonic particle deposition) for Depot repair. The process utilizes aluminum and/or aluminum alloys as a cost-effective, environmentally acceptable technology to provide surface protection and a repair/rebuild methodology to a variety of magnesium alloy components for use on Army and Navy helicopters and advanced fixed-wing aircraft for the Air Force.