PHM 2019

11th Annual Conference of the Prognostics and Health Management Society

phmsociety

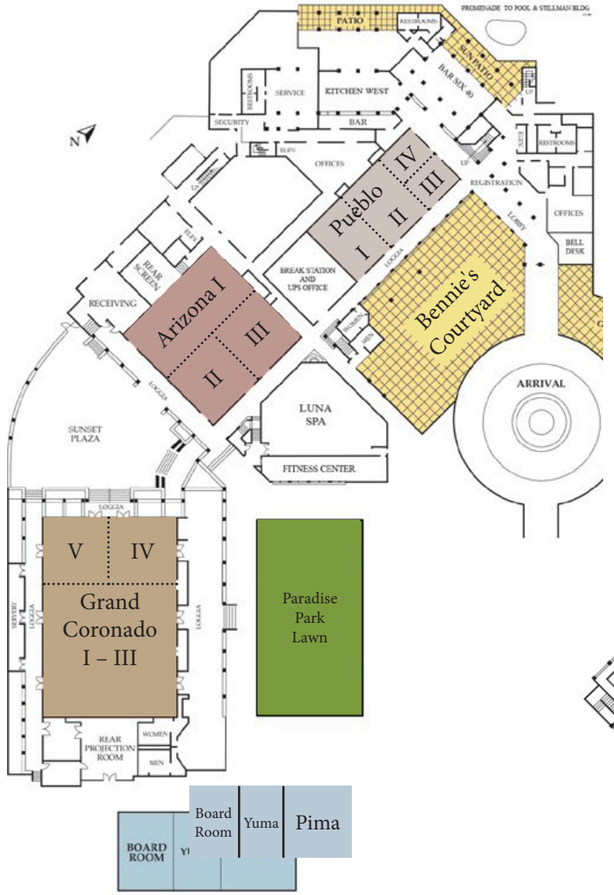
Scottsdale, AZ

September 21 – 26, 2019

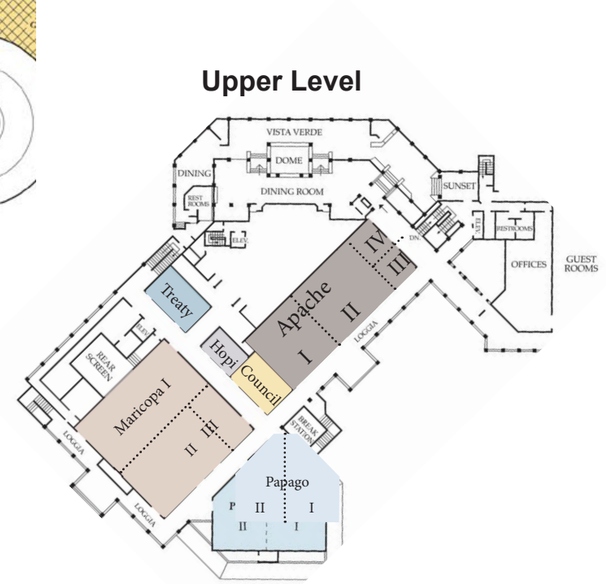
www.phmconference.org

www.phmsociety.org

Lower Level



Upper Level



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Welcome to Scottsdale!

Welcome to historic Scottsdale for the 2019 Annual Conference of the Prognostics and Health Management (PHM) Society. This marks the 11th year of the conference, and will attract greater participation and offer richer programs than ever before to continue our success story.

Scottsdale is a popular winter vacation mecca for entire North-America in the area of Arizona known as the "Valley of the Sun," and with a slogan of "The West's Most Western Town." A tiny farming community of 2,000 people covering only 1 square mile in 1951 north of Phoenix, Scottsdale has become a vibrant city of more than 200,000 residents encompassing nearly 200 square miles. Its many golf courses and resorts attract visitors from around the world. Art galleries abound amid the towering palm trees, purple shadowed mountains, and pastel landscapes. The city boasts more than 300 sunny days per year. The lively restaurants, nightclubs, and cultural and sporting events add a metropolitan touch, yet cowboy ranches and Indian reservations are a brief ride away. In addition to its booming tourism industry, Scottsdale has become a diverse high technology center and is becoming recognized as a leader in health care and medical research. It offers a vast array of recreational activities, including biking, hiking, white water rafting, horseback riding, and ballooning. The arts are flourishing in the city, which has its own symphony orchestra and more art showcases per capita than almost any other city in the world. The conference week also overlaps with the "Fall Arizona Restaurant Week," which brings you the local savor and old favorites to you from over 100 participating restaurants.

The Scottsdale Resort at McCormick Ranch Scottsdale Arizona is at the Crossroads of Everything in Scottsdale. Beautifully reimagined to reflect the beauty, warmth and community spirit of the Sonoran Desert, the Scottsdale Resort at McCormick Ranch welcomes you to a secluded oasis. Where conversations flow and connections are made, you'll discover a AAA Four Diamond retreat for the senses. Celebrate the pampering indulgence of Luna Spa. Find inspiration throughout event venues. Savor the locally sourced creations of artisan chefs. Schedule a sunrise tee time on nearby McCormick Ranch Golf Course. Or, simply enjoy the sunshine in one of our poolside cabanas. However you wish to spend your days, your next unforgettable experience awaits just off the beaten path.

The program for the PHM 2019 Conference is rich with technical content and the events offer many opportunities to make and renew professional connections across the national and international PHM community. Please enjoy this program, but also be sure to step outside the conference venue and soak up the sights and sounds of Scottsdale and Phoenix, an area rich in western history and diversity. We hope you have an enjoyable and productive week with us in Scottsdale!

Wolfgang Fink and Ginger Shao
2019 Conference Co-Chairs

The Conference

The Prognostics and Health Management Society (PHM Society) welcomes you to its 11th annual international conference. As the Society's annual premier event, the 2019 PHM Conference brings together the global community of PHM experts from industry, academia, and government in diverse application areas, such as, but not limited to, unmanned systems, wind energy, oil and gas, aerospace, transportation, automotive, precision agriculture, commercial space, human health & performance, smart manufacturing, and industry AI. In addition to technical paper sessions, the conference features a workshop on Measurement and Evaluation for PHM in Manufacturing, invited expert panels on a plurality of critical issues and applications, a doctoral symposium, a dedicated poster session, Luminary and Keynote speakers, and tutorials free to all registrants. Leading companies and research institutions will exhibit their products and demonstrate their technologies during the event. A PHM Data Challenge will be carried out in parallel and the results will be presented during the conference. The PHM Society features also two, two-day intensive short courses (PHM Fundamentals and Analytics for PHM) before the start of the main conference. Several social events will round up the program by providing ample opportunities for participants to connect and network with colleagues, including a career fair, diversity & inclusion breakfast, and, for the first time, a Golf tournament "PHM goes PGA" at the end of the conference.

phmconference.org

What Sets This Conference Apart from Other Events

A major differentiator for the PHM Society is its contemporary approach toward copyright: the Society does not take ownership of your work! Instead, authors retain copyright through a Creative Commons License while allowing the PHM Society to distribute their work broadly through modern media at no cost to the authors. As a result, your original articles will reach the entire world for free and without access restrictions.

The conference includes high-quality tutorials, and original contributions submitted as full-length papers and posters. All submissions are reviewed by up to four experts in the field based on the criteria of originality, significance, quality, and clarity. The conference proceedings are published on the web for unrestricted access by the global scholarly and applications community.

Lastly, the conference has taken pride in building up its industry-focused panel sessions over the last several years. Most conferences do an outstanding job highlighting cutting-edge technical research, yet fail to offer a healthy amount of contributions from industry leaders who cannot necessarily share their work through technical publications. Our conference does both! Our panel sessions have featured, and will continue to feature, PHM practitioners with real-world experience who share candid insight as to how PHM has impacted their organizations.

The PHM Society

For years, the field of PHM was represented under a variety of banners, including aerospace, reliability, failure analysis and prevention, mechanical engineering, and others. PHM is broader than any single field of study. The PHM Society was established to unite the diverse PHM community and to establish PHM as a legitimate scientific and engineering discipline that draws from electrical, mechanical, civil, and chemical engineering, computer and materials science, reliability, test and measurement, artificial intelligence, healthcare, physics, smart manufacturing, and economics. We invite you to establish PHM as a meta-discipline that synergizes these fields.

PHM Society membership is free and entitles you to full access to papers, tutorials and proceedings—join or update your profile today!

Sincere appreciation to the sponsors of this brochure!

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Saturday, September 21, 2019			
Time \ Location	PHM Fundamentals Short Course Arizona II	PHM Data Analytics Short Course Arizona III	Location / Time
8:00 – 10:00	**PHM Fundamentals Short Course Day 1** *Separate Registration Required*	**PHM Data Analytics Short Course Day 1** *Separate Registration Required*	8:00 – 10:00
10:00 – 10:15	Break	Location: Arizona I	10:00 – 10:15
10:15 – 12:00	**PHM Fundamentals Short Course Day 1**	**PHM Data Analytics Short Course Day 1**	10:15 – 12:00
12:00 – 1:00	Lunch	Location: Arizona I	12:00 – 1:00
1:00 – 3:15	**PHM Fundamentals Short Course Day 1**	**PHM Data Analytics Short Course Day 1**	1:00 – 3:15
3:15 – 3:30	Break	Location: Arizona I	3:15 – 3:30
3:30 – 5:30	**PHM Fundamentals Short Course Day 1**	**PHM Data Analytics Short Course Day 1**	3:30 – 5:30

Optional PHM Fundamentals Short Course Details and Agenda

September 21 – 22, Location: Arizona II
Separate Registration Required
Course Leaders: Dr. George Vachtsevanos (Georgia Tech) and Dr. Karl Reichard (Pennsylvania State University)
Course Administrator: Jeff Bird (TECnos)

This introductory course will be taught by recognized international experts in the PHM field and will cover the current state of the art in PHM technologies, sensors and sensing strategies, data mining tools, CBM+ technologies, novel diagnostic and prognostic algorithms as well as a diverse array of application examples/case studies. It is addressed to engineers, scientists, operations managers, educators, small business principals and system designers interested to learn how these emerging technologies can impact their work environment. Through a lecture (with Q&A), networking and workshop format with specialist experts, you will:

1. Establish a baseline for defining the extent and capabilities of PHM, specifically needs and organization
2. Identify specific details of PHM Applications (metrics, sensors, cost benefits, reliability) and PHM Methods (diagnostics, prognostics, data driven methods and uncertainty)
3. Identify issues and needs and a way forward including Continuing Professional Development
4. Examine case studies of PHM applications across diverse domains to identify solutions and impacts
5. Plan a PHM application in two mini workshop settings with expert group leaders

Topics Include:

- Introduction to PHM (Taxonomy, scope, basics, standards- for all talks
- Deriving Requirements for PHM (Basics and illustrative examples)
- PHM Performance Metrics (Basics and illustrative examples)
- Diagnostics Methods (Basics and illustrative examples)
- *Case Study for requirements/metrics (Description of an application)*
- Prognostics (Basics and illustrative examples including uncertainty)
- Data Analytics Methods (Basics and illustrative examples)
- *Prognostics Case Studies (2 case studies for prognosis and data analytics information)*
- Sensors & Data Processing (Available/Required data and organization)
- *Analysis mini workshop (Small group data design activity with worksheets)*
- CBM+ and IVHM Technologies (Basics and illustrative examples)
- PHM Management Cost Benefit Analysis (Basics with cost Benefits, examples)
- Plenary- Issues and Needs (Review to compile collected issues from all participants)
- Reliability and Life Cycle Management (Linking reliability and PHM approaches)
- *Case Study Workshop Introduction (Small group activity builds on data design mini)*
- Fielded Systems Case Studies-1 (2 case studies for CBM and Reliability)
- Fielded Systems Case Studies-2 (3rd case study for CBA)
- *Case Study Mini workshop (Small group activity and reporting)*
- Way forward (Paths, Resources, Continuing Professional Development)

Saturday, September 21, 2019

8:00 – 10:00 Session 1:
Welcome and Introductions
Introduction to PHM
Deriving Requirements for PHM
PHM Performance Metrics

10:00 – 10:15 Break

10:15 – 12:00 Session 2:
Diagnostics Methods
Diagnostics Case Studies

12:00 – 1:00 Lunch (provided)

1:00 – 3:15 Session 3:
Prognostics
Data Analytics Methods
Prognostics Case Studies

3:15 – 3:30 Break

3:30 – 5:30 Session 4:
Sensors and Data Processing
Analysis Mini–Workshop
Summary of Workshop Results

7:30 – ? Non-hosted dinner with all participants

Sunday, September 22, 2019

8:30 – 10:00 Session 5:
CBM+ and IVHM Technologies
PHM Management Cost Benefit Analysis
Plenary—Issues and Needs

10:00 – 10:15 Break

10:15 – 12:00 Session 6:
Reliability and Life Cycle Management
Fielded Systems Case Studies – 1

12:00 – 1:00 Lunch (provided)

1:00 – 3:15 Session 7:
Fielded Systems Case Studies – 2
Case Study Mini–Workshop Introduction
Case Study Mini–Workshop

3:15 – 3:30 Break

3:30 – 5:30 Session 8:
Way Forward
Wrap up with Evaluation Forms

Sunday, September 22, 2019			
Time \ Location	PHM Fundamentals Short Course Arizona II	PHM Data Analytics Short Course Arizona III	Location / Time
1PM – 5PM	Registration	Location: Pueblo III	1PM – 5PM
8:00 – 10:00	**PHM Fundamentals Short Course Day 2** *Separate Registration Required*	**PHM Data Analytics Short Course Day 2** *Separate Registration Required*	8:00 – 10:00
10:00 – 10:15	Break	Location: Arizona I	10:00 – 10:15
10:15 – 12:00	**PHM Fundamentals Short Course Day 2**	**PHM Data Analytics Short Course Day 2**	10:15 – 12:00
12:00 – 1:00	Lunch	Location: Arizona I	12:00 – 1:00
1:00 – 3:15	**PHM Fundamentals Short Course Day 2**	**PHM Data Analytics Short Course Day 2**	1:00 – 3:15
3:15 – 3:30	Break	Location: Arizona I	3:15 – 3:30
3:30 – 5:30	**PHM Fundamentals Short Course Day 2**	**PHM Data Analytics Short Course Day 2**	3:30 – 5:30

Optional PHM Data Analytics Short Course Details and Agenda

September 21 – 22, Location: Arizona III
Separate Registration Required
Course Leader: Dr. Neil Eklund (Analatom)
Course Administrator: Jeff Bird (TECnos)

This course is intended for engineers, scientists, and managers who are interested in data driven methods for asset health management. You will learn how to identify potential data driven projects, visualize data, screen data, construct and select appropriate features, build models of assets from data, evaluate and select models, and deploy asset monitoring systems. By the end of the course, you will have learned the essential skills of processing, manipulating and analyzing data of various types, creating advanced visualizations, detecting anomalous behavior, diagnosing faults, and estimating remaining useful life. Note that this course is an advanced course with only a brief, high-level overview of PHM presented - students are expected to know the basics of PHM already. New practitioners are encouraged to take the fundamentals course or contact the course leader to examine their background and skills.

The course is about two thirds lecture, and an optional one third hands-on lab. Students who elect to take the lab will be ex expected to bring a laptop with analytics software (R, Python, Matlab, or something similar) that they are familiar with pre-installed. Lab example solutions will be presented in Python.

Topics Include:

- Overview of Data-driven PHM
- Review of Fundamental Statistics
- Data Visualization
- Machine Learning – Introduction and Concepts
- Data Transformation & Feature Extraction
- Classification
- Regression
- Introduction to Neural Networks
- *Hands-on Lab*
- Feature Selection
- Characterizing Performance
- Model Selection
- Anomaly Detection
- Deep Learning I
- Deep Learning II
- Applications
- Practical Matters
- *Hands-on Lab*

Saturday, September 21, 2019

8:00 – 10:00 Session 1:
Welcome and Introductions
Overview of Data-driven PHM
Review of Basic Statistics
Exploratory Data Analysis

10:00 – 10:15 Break

10:15 – 12:00 Session 2:
Machine Learning—Introduction and Concepts
Data Transformation and Feature Extraction
Classification

12:00 – 1:00 Lunch (provided)

1:00 – 3:15 Session 3:
Regression

3:15 – 3:30 Break

3:30 – 5:30 Session 4:
Hands-on Lab

7:30 – ? Non-hosted dinner with all participants

Sunday, September 22, 2019

8:30 – 10:00 Session 5:
Feature Selection
Characterizing Performance

10:00 – 10:15 Break

10:15 – 12:00 Session 6:
Model Selection
Anomaly Detection

12:00 – 1:00 Lunch (provided)

1:00 – 3:15 Session 7:
Applications
Practical Matters

3:15 – 3:30 Break

3:30 – 5:30 Session 8:
Hands-on Lab
Wrap up with Evaluation Forms

Monday, September 23, 2019				
Time \ Location	Doctoral Symposium	Deep Learning Workshop	ME4PHM Workshop	Location / Time
	Pueblo I & II	Arizona II & III	Arizona I	
7AM – 5PM	Registration		Location: Pueblo III	7AM – 5PM
7:00 – 8:00			Breakfast (provided)	7:00 – 8:00
8:00 – 9:15	DS Breakfast (provided)	*Free Time*	**Measurement and Evaluation for PHM in Manufacturing (ME4PHM) Workshop** *(NIST)*	8:00 – 11:15
9:15 – 12:30	**Doctoral Symposium**			
			Lunch on your own	11:15 – 12:30
12:30 – 1:30	DS Lunch (provided)	**PHM Applications Of Deep Learning Workshop** Neil Eklund (*Analatom*)	**Measurement and Evaluation for PHM in Manufacturing (ME4PHM) Workshop** *(NIST)*	12:30 – 4:30
1:30 – 5:00	**Doctoral Symposium**			
5:00 – 5:30	*Free Time*			4:30 – 5:30
5:30 – 7:30	**Opening Welcome Reception with Cocktails Location: Bennie's Courtyard**			5:30 – 7:30

PHM Applications Of Deep Learning Workshop

Monday, 12:30 – 4:30, Location: Arizona II & III
Workshop Leader: Dr. Neil Eklund (Analatom)

Deep learning has recently achieved significant breakthroughs in many different domains, including computer vision, language processing, genomics, and speech recognition; e.g., AlphaGo and AlphaZero have achieved super-human performance in complex games without human input. Despite these encouraging results, these techniques have seen little adoption by industry for PHM applications. There are several obstacles that need to be surmounted to enable the broad adoption of deep learning for PHM:

- Limited number of representative training samples, particularly for different types of faulty conditions and representative time-to-failure trajectories
- Appropriate benchmark datasets to compare the progress of newly developed algorithms
- Variability of operating and environmental conditions to appropriately transfer the learnt patterns between different operating conditions
- Heterogeneity of condition monitoring signals, system configurations, and operating conditions

This half-day workshop on the afternoon of 23 September will provide a forum for PHM researchers and practitioners to discuss the potential, applicability, benefits, challenges, and current obstacles of deep learning for PHM applications. The focus will be on theory and application of deep learning to anomaly detection, condition monitoring, diagnostics, and prognostics.

Measurement and Evaluation for PHM in Manufacturing (ME4PHM) Workshop

Monday, 7:00 – 4:30, Location: Arizona I
Workshop Leaders: Brian A. Weiss (NIST) and Michael Brundage (NIST)

This heavily discussion-based event will feature panel presentations and discussions from industry, government, and academia operating/focused in advancing monitoring, diagnostic, and prognostic (collectively known as prognostic and health management (PHM)) capabilities within manufacturing operations with a specific emphasis on how PHM technologies are evaluated. Participants (and expected audience members) will offer a diverse cross-section of technology developers, integrators, end-users/manufacturers (from small to large), and researchers to discuss what is working well, common challenges that need to be addressed, where the community's priorities should be focused, and how technological adoption can be sped in a cost-effective manner.

It is envisioned that this event will be documented in a resultant report that will present the best practices, lessons learned, challenges, and needs in measuring, verifying, and validating PHM technologies applicable to or active in manufacturing.

BENEFITS OF PARTICIPATION

- Hear from other industry professionals (including personnel from large and small manufacturers) about their challenges, needs, and best practices to measure the performance of monitoring, diagnostic, and prognostic technologies
- Understand what technologies are actively being developed and integrated to enhance your ability measure monitoring, diagnostic, and prognostic solutions
- Learn the latest measurement techniques that can be applied within your own manufacturing environments
- Builds upon the success of the 2018 Industry Forum: Monitoring, Diagnostics, and Prognostics for Manufacturing Operations that was documented in a publicly-available report.

Monday, September 23, 2019

7:00 – 8:00 Breakfast (provided)
8:00 – 8:15 Welcome/Introduction
Brian Weiss and Michael Brundage *(NIST)*
8:15 – 9:40 Large Manufacturing – Challenges, Needs, and Best Practices to Verify and Validate PHM Technologies
Sarah Lukens *(General Electric)*; Greg Colvin *(Honeywell)*; TBD *(Foxconn)*; Nicholas Propes *(Seagate)*; and Maria Seale *(U.S. Army ERDC)*; TBD *(Collins Aerospace)*
9:40 – 9:55 Break
9:55 – 11:15 Small Manufacturing – Challenges, Needs, and Best Practices to Verify and Validate PHM Technologies
Radu Pavel *(TechSolve)*; Sara Fuller *(Mississippi State)*; Brad Smith *(Ludowici)*; and Luis Gonzalez-Mendez *(Trividia Health)*
11:15 – 12:30 Lunch on your own
12:30 – 2:00 Technology Development & Integration – Emergent PHM and the Capabilities that must be Assessed
David Siegel *(Predictronics)*; Mark Walker *(D2K Technologies)*; Ed Spence *(Machine Instrumentation)*; Frank Zahiri *(U.S. Air Force Sustainment Center)*; and Sankaran Mahadevan *(Vanderbilt University)*
2:00 – 2:15 Break
2:15 – 3:40 Measurement and Evaluation Research – Developing Independent V&V of PHM
Brian Weiss *(NIST)*; Michael Brundage *(NIST)*; Michael Sharp *(NIST)*; and Doug Thomas *(NIST)*
3:40 – 4:10 Assessment of Dfferent Industrial AI techniques for PHM
Xiondong 'Alex' Jia *(University of Cincinnati)*
4:10 – 4:30 Wrap-up

Doctoral Symposium

Monday, 8:00 – 5:00, Location: Pueblo I & II
Symposium Chairs: Jamie Coble (University of Tennessee, Knoxville) and Felipe Viana (University of Central Florida)

The Doctoral Symposium provides an opportunity for graduate students to present their research interests and plans at a formative stage in their research. The students will receive structured guidance from a panel of distinguished researchers as well as comments from conference participants and fellow students in a collegial setting. The PHM Society Doctoral Symposium will be held as a workshop on the first day of the conference. The panelists for the DS are:

Matteo Corbetta *(NASA Ames Research Center)*
Felipe Parages *(Uptake)*
Shawn Sheng *(National Renewable Energy Laboratory)*
Felipe Viana *(University of Central Florida)*

Social Program

Sponsor Exhibits
Throughout Conference, Location: Coronado IV & V

Opening Welcome Reception with Cocktails
Monday, 5:30 – 7:30, Location: Bennie's Courtyard

Cocktail Reception with Posters
Tuesday, 5:30 – 8:00, Location: Coronado I – III

Student Social Pool Event
Tuesday, 8:00 – 10:00, Location: McCormick Hotel pool-side

Network with the PHM community students in a relaxing atmosphere by the pool. A perfect evening to socialise and enjoy food and refreshments from the hotel pool bar & grill. Pool facilities will stay open, so don't forget your swim suit!

PHM Conference 11th Anniversary Banquet
Wednesday, 6:00 – 10:00, Location: Botanical Gardens
(for guest tickets, please see Registration Desk)

Diversity Outreach Breakfast
Thursday, 7:00 – 8:00, Location: Coronado I – III

Did you know that PHMS has recently committed to a Diversity Statement? Join a distinguished panel of PHM experts for a discussion on Inclusion and take a closer look at how PHMS can foster an inclusive environment so all individuals can contribute their best to the success of the PHM field.

This is a chance for your voice to be heard and YOU can help shape the inclusive community of PHMS. A full breakfast will be served, so come early!

Mobile App

The PHM Conference will be using the Whova mobile app this year. Easily access the most up-to-date agenda information, read full PDF versions of all papers, connect with other attendees, and much more using the free app on your phone or tablet. Get "Whova" from the App Store or Google Play and sign in with your e-mail account. Search for the **PHM2019** event and, if prompted, use passcode **phmsociety**.

http://whova.com/portal/phm_201909

www.whova.com/download

Doctoral Symposium Agenda

Monday, September 23, 2019

8:00 – 9:15 Breakfast (provided for participants and panelists)
9:15 – 9:30 Doctoral Symposium Welcome
9:30 – 10:00 Presentation #1 (10 min)
A Physics-based Deep Learning Technique for Prognostics – Khaled Akkad *(University of Illinois–Chicago)*
Panelist Feedback / Audience Q&A
10:00 – 10:30 Presentation #2 (10 min)
Vibration-based Condition Monitoring of Industrial Drivetrains Operating under Non-stationary Conditions – Madhurjya Dev Choudhury *(University of Auckland)*
Panelist Feedback / Audience Q&A
10:30 – 11:00 Break
11:00 – 11:30 Presentation #3 (10 min)
Methodology of Adaptive Prognostics and Health Management Using Streaming Data in Big Data Environment – Jianshe Feng *(University of Cincinnati)*
Panelist Feedback / Audience Q&A
11:30 – 12:00 Presentation #4 (10 min)
Multimodality Information Fusion for Aging Pipe Strength and Toughness Estimation Using Bayesian Networks – Jie Chen *(Arizona State University)*
Panelist Feedback / Audience Q&A
12:00 – 12:30 Presentation #5 (10 min)
Probabilistic Risk Assessment and Mitigation for UAS Safety and Traffic Management – Jueming Hu *(Arizona State University)*
Panelist Feedback / Audience Q&A
12:30 – 1:30 Lunch (provided for participants and panelists)
1:30 – 2:00 Presentation #6 (10 min)
Adapting Approximate Entropy as a Health Indicator of Rotating Machinery for Estimation of Remaining Useful Life – Cody Walker *(University of Tennessee)*
Panelist Feedback / Audience Q&A
2:00 – 2:30 Presentation #7 (10 min)
Novel Waveforms, Models, Algorithms for Cable Health Monitoring – Xuan Wang *(University of South Carolina)*
Panelist Feedback / Audience Q&A
2:30 – 3:00 Break
3:00 – 3:30 Presentation #8 (10 min)
Deep Learning Enable Diagnostics and Prognostics of Machine Health Condition – Wo Jae Lee *(Purdue University)*
Panelist Feedback / Audience Q&A
3:30 – 4:00 Presentation #9 (10 min)
A Framework for Resilience-Informed Decision-Making in Early Design – Daniel Hulse *(Oregon State University)*
Panelist Feedback / Audience Q&A
4:00 – 4:30 Presentation #10 (10 min)
A Framework to Interpret Deep Learning-Based Health Management System with Human Interactions – Namkyoung Lee *(University of Maryland)*
Panelist Feedback / Audience Q&A
4:30 – 4:45 Panelists Final Thoughts
4:45 – 5:00 Feedback from Students & Audience

Tuesday, September 24, 2019							Tuesday, September 24, 2019			
Location / Time	Technical Paper Sessions			Tutorial Sessions	Career Fair		Panel Sessions	Technology Demos & Product Showcases		Location / Time
	Arizona II	Arizona III	Pueblo I & II	Apache I	Apache II		Arizona I	Apache III	Apache IV	
7AM – 5PM	Registration				Location: Pueblo III		Registration		Location: Pueblo III	7AM – 5PM
7:00 – 8:00	Continental Breakfast			Location: Grand Coronado I – III			Continental Breakfast	Location: Grand Coronado I – III		7:00 – 8:00
8:00 – 8:50	Opening Remarks Location: Grand Coronado I – III **Keynote Speaker: Kevin Sullivan (*Arizona Commerce Authority*) – "Arizona As a Place of Commerce and Business"** **Keynote Speaker: Josh Melin (*Honeywell*) – "Lessons Learned in Predictive Analytics for Airline Maintenance Operations"**						Opening Remarks Location: Grand Coronado I – III **Keynote Speaker: Kevin Sullivan (*Arizona Commerce Authority*) – "Arizona As a Place of Commerce and Business"** **Keynote Speaker: Josh Melin (*Honeywell*) – "Lessons Learned in Predictive Analytics for Airline Maintenance Operations"**			8:00 – 8:50
8:50 – 9:00	Break			Location: Grand Coronado IV & V			Break	Location: Grand Coronado IV & V		8:50 – 9:00
9:00 – 10:30	Paper Session 1A: **Real-time PHM and Deployment**	Paper Session 1B: **Diagnostics I**	Paper Session 1C: **Prognostics I**	Tutorial Session 1: **Introduction to Prognostics** Matteo Corbetta (*SGT, NASA Ames Research Center*)	Career Fair: General Session 1 **Collins Aerospace • GE** (see page TBD for details)		Panel Session 1: **PHM for Aviation Maintenance Repair Organizations** Frank Zahiri (*USAF Warner Robins ALC*) and Andy Hess (*The Hess PHM Group*)	Tech Demo 1: **Condition Indicator Design & RUL Estimation using MATLAB** *MathWorks*	*Reserved*	9:00 – 10:30
10:30 – 10:45	Break			Location: Grand Coronado IV & V			Break	Location: Grand Coronado IV & V		10:30 – 10:45
10:45 – 12:15	Paper Session 2A: **PHM Methods**	Paper Session 2B: **PHM Application - Wind Turbines**	Paper Session 2C: **Anomaly Detection**	*Reserved*	Career Fair Follow-up Discussions 1 **Collins Aerospace**		Panel Session 2: **PHM for Manufacturing** Greg Vogl (*TechSolve*)	*Reserved*	Tech Demo 2: **Connected Ecosystem for Aerospace Intelligence and PHM** *Collins Aerospace*	10:45 – 12:15
12:15 – 1:30	Conference Lunch Location: Grand Coronado I – III **Keynote Speaker: Stan Martin (*Oak Ridge National Laboratory*)** **"How Bio Fuels and Other Renewable Energy Sources May Impact Global Climate Change and Alter the Course of History"**						Conference Lunch Location: Grand Coronado I – III **Keynote Speaker: Stan Martin (*Oak Ridge National Laboratory*)** **"How Bio Fuels and Other Renewable Energy Sources May Impact Global Climate Change and Alter the Course of History"**			12:15 – 1:30
1:30 – 3:00	Invited Paper Session 3A: **Blockchain in Control & Aerospace**	IJPHM Paper Session 3B: **Deep Learning for Aviation**	Paper Session 3C: **Data-Driven Prognostics I**	*Reserved*	Career Fair Follow-up Discussions 2 **GE**		Panel Session 3: **Automotive PHM Emerges** Azeem Sarwar (*General Motors*)	Tech Demo 3: **Title TBD** *Honeywell*	*Reserved*	1:30 – 3:00
3:00 – 3:15	Break			Location: Grand Coronado IV & V			Break	Location: Grand Coronado IV & V		3:00 – 3:15
3:15 – 4:45	Invited Paper Session 4A: **Design Consideration for PHM**	Paper Session 4B: **Deep Learning Theory**	Paper Session 4C: **Predictive Maintenance**	*Reserved*	Career Fair Follow-up Discussions 3 **TBD**		Panel Session 4: **PHM for Space Applications** Derek DeVries (*Northrop Grumman*) and Andy Hess (*The Hess PHM Group*)	*Reserved*	Tech Demo 4: **Title TBD** *Siemens*	3:15 – 4:45
4:45 – 5:30	Free Time						Free Time			4:45 – 5:30
5:30 – 8:00	Cocktail Reception with Posters Location: Grand Coronado I – III						Cocktail Reception with Posters Location: Grand Coronado I – III			5:30 – 8:00
8:00 – 10:00	Student Social Dinner Location: Twisted Vine Pool Bar and Grill						Student Social Dinner Location: Twisted Vine Pool Bar and Grill			8:00 – 10:00

Paper Session 1A: Real-time PHM and Deployment
Tuesday, 9:00 – 10:30, Room: Arizona II
Session Chair: Marcos Orchard (Universidad de Chile)

Deployment of Prognostics to Optimize Aircraft Maintenance: A Literature Review – Jorben Pieter Sprong[1], Xiaoli Jiang[2], Henk Polinder[3] ([1,2,3]*Delft U. of Technology*)

Prognostics As-A-Service: A Scalable Cloud Architecture for Prognostics – Jason Watkins[1], Christopher Teubert[2], John Ossenfort[3] ([1,3]*SGT, Inc., NASA Ames;* [2]*NASA Ames*)

A Methodology for the Experimental Validation of an Aircraft ECS Digital Twin Targeting System Level Diagnostics – Shafayat Hasan Chowdhury[1], Fakhre Ali[2], Ian K. Jennions[3] ([1,2,3]*Cranfield U.*)

Paper Session 1B: Diagnostics I
Tuesday, 9:00 – 10:30, Room: Arizona III
Session Chair: Nam-ho Kim (University of Florida)

Bearing Condition Monitoring based on the Indicator Generated in Time-frequency Domain – Teng Wang[1], Zheng Liu[2], Guoliang Lu[3] ([1,2]*U. of British Columbia - Okanagan;* [3]*Shandong U.*)

Fault Detection of a Reusable Rocket Engine using Phase Plane Trajectory of Feature Vectors – Seiji Tsutsumi[1], Miki Hirabayashi[2], Daiwa Sato[3], Masaharu Abe[4], Kaname Kawatsu[5], Masaki Sato[6], Toshiya Kimura[7], Tomoyuki Hashimoto[8] ([1,2,3,5,6,7,8]*JAXA;* [4]*Ryoyu Systems*)

Order Tracking Using Variational Mode Decomposition to Detect Gear Faults under Speed Fluctuations – Madhurjya Dev Choudhury[1], Liu Hong[2], Jaspreet Singh Dhupia[3] ([1,3]*U. of Auckland;* [2]*Wuhan U. of Technology*)

Paper Session 1C: Prognostics I
Tuesday, 9:00 – 10:30, Room: Pueblo I & II
Session Chair: Ramin Moradi (University of Maryland)

Wheel Bearing Fault Isolation and Prognosis Using Acoustic Based Approach – Jianshe Feng[1], Xinyu Du[2], Mutasim Salman[3] ([1]*U. of Cincinnati;* [2,3]*GM*)

Physics-Informed Neural Networks for Corrosion-Fatigue Prognosis – Arinan Dourado[1], Felipe A. C. Viana[2] ([1,2]*U. of Central Florida*)

Multivariate Bernoulli Logit-Normal Model for Failure Prediction – Huijuan Shao[1], Xinwei Deng[2], Chi Zhang[3], Shuai Zheng[4], Hamed Khorasgani[5], Ahmed Farahat[6], Chetan Gupta[7] ([1,3,4,5,6,7]*Hitachi;* [2]*Virginia Tech*)

Paper Session 2A: PHM Methods
Tuesday, 10:45 – 12:15, Room: Arizona II
Session Chair: Jose Celaya (Schlumberger)

A Survey of Flight Anomaly Detection Methods: Challenges and Opportunities – Vivian Rowoli Igenewari[1], Zakwan Skaf[2], Ian K. Jennions[3] ([1,2,3]*Cranfield U.*)

A Study on PHM Method Suitable for Motor-Driven Commercial Vehicle – Hong Suk Chang[1], Jong Chan Park[2] ([1,2]*Hyundai*)

Kinematic Frequencies of Rotating Equipment Identified with Sparse Coding and Dictionary Learning – Sergio Martin-del-Campo[1], Fredrik Sandin[2], Stephan Schnabel[3] ([1,2]*Luleå U. of Technology;* [3]*SKF*)

Paper Session 2B: PHM Application - Wind Turbines
Tuesday, 10:45 – 12:15, Room: Arizona III
Session Chair: Aramis Perez (University of Costa Rica)

Wind Turbine Main Bearing Fatigue Life Estimation with Physics-informed Neural Networks – Yigit Anil Yucesan[1], Felipe A. C. Viana[2] ([1,2]*U. of Central Florida*)

Adaptive Machine Learning Approach for Fault Prognostics based on Normal Conditions - Application to Shaft Bearings of Wind Turbine – Koceila Abid[1], Moamar Sayed-Mouchaweh[2], Cornez Laurence[3] ([1,2]*IMT Lille Douai;* [3]*CEA Tech*)

A Diagnostic Framework for Wind Turbine Gearboxes Using Machine Learning – Sofia Koukoura[1], James Carroll[2], Alasdair McDonald[3] ([1,2,3]*U. of Strathclyde*)

Paper Session 2C: Anomaly Detection
Tuesday, 10:45 – 12:15, Room: Pueblo I & II
Session Chair: Jae Yoon (National Oilwell Varco)

Isolation and Localization of Unknown Faults Using Neural Network-Based Residuals – Daniel Jung[1] ([1]*Linkoping U.*)

Automatic Indexation of Turbofan Data to Identify Anomalous Behaviors – Jerome Lacaille[1], Cynthia Faure[2], Madalina Olteanu[3], Marie Cottrell[4] ([1]*Safran Aircraft Engines;* [2,3,4]*Université Paris 1, Panthéon-Sorbonne*)

Data-Driven Detection of Anomalies and Cascading Failures in Traffic Networks – Sanchita Basak[1], Afiya Ayman[2], Aron Laszka[3], Abhishek Dubey[4], Bruno Leao[5] ([1,4]*Vanderbilt U.;* [2,3]*U. of Houston;* [5]*Siemens*)

Invited Paper Session 3A: Blockchain in Control & Aerospace
Tuesday, 1:30 – 3:00, Location: Arizona II
Session Chair: Sandeep Gulati (Zyomed)

A Blockchain-Backed Registry for Health-Ready Components & Systems – TBD (*TBD*)

Blockchains for IoT Transactional Integrity and Cybersecurity in High-Density Applications – TBD (*TBD*)

A Consortium Digital Data Marketplace enabling AI development via Smart Contracts – TBD (*TBD*)

IJPHM Paper Session 3B: Deep Learning for Aviation
Tuesday, 1:30 – 3:00, Location: Arizona III
Session Chair: Neil Eklund (Analatom)

TrajecNets: Online Failure Evolution Analysis in 2D Space – Nauman Shahid[1], Anarta Ghosh[2] ([1,2]*United Technologies Research Center*)

Fully Unsupervised Feature Alignment for Critical System Health Monitoring with Varied Operating Conditions – Gabriel Michau[1], Chetan Kulkarni[2], Kai Goebel[3], Olga Fink[2] ([1,4]*ETH Zurich;* [2]*SGT, Inc., NASA Ames;* [3]*Luleå U. of Technology*)

Hybrid Deep Fault Detection and Isolation: Combining Deep Neural Networks and System Performance Models – Manuel Arias Chao[1], Olga Fink[2] ([1,2]*ETH Zurich*)

Paper Session 3C: Data-Driven Prognostics I
Tuesday, 1:30 – 3:00, Room: Pueblo I & II
Session Chair: Wei zhong Yan (GE Global Research Center)

A Novel Similarity-based Method for Remaining Useful Life Prediction Using Kernel Two Sample Test – Xiaodong Jia[1], Haoshu Cai[2], Yuanming Hsu[3], Wenzhe Li[4], Jianshe Feng[5], Jay Lee[6] ([1,2,3,4,5,6]*U. of Cincinnati*)

A Hybrid PSO-SVM Based Method for Degradation Process Prediction of Reciprocating Seal – Madhumitha Ramachandran[1], Jon Keegan[2], Zahed Siddique[3] ([1,2,3]*U. of Oklahoma*)

Remaining Useful Life Prediction of Bearings with Ensemble Learning – Junchuan Shi[1], Kai Goebel[2], Dazhong Wu[3] ([1,3]*U. of Central Florida;* [2]*PARC*)

Invited Paper Session 4A: Design Consideration for PHM
Tuesday, 3:15 – 4:45, Room: Arizona II
Session Chair: Ian Jennions (Cranfield University)

Best Practices Framework for Improving Maintenance Data Quality to Enable Asset Performance Analytics – Sarah Lukens[1], Manjish Naik[2], Kittipong Saetia[3], Xiaohui Hu[4] ([1,2,3,4]*GE*)

Using Value Assessment to Drive PHM System Development in Early Design – Daniel Hulse[1], Christopher Hoyle[2], Kai Goebel[3], Irem Tumer[4] ([1,2,4]*Oregon State U.;* [3]*PARC*)

†Ethics in Prognostics and Health Management – Kai Goebel[1], Brian Smith[2], Anupa Bajwa[3] ([1]*PARC, LuleåTechnical U.;* [2,3]*NASA Ames*)

Paper Session 4B: Deep Learning Applications
Tuesday, 3:15 – 4:45, Room: Arizona III
Session Chair: Olga Fink (ETH Zürich)

Multi-Source Domain Adaptation for Intelligent Fault Diagnosis of Rolling Element Bearings: A Novel Deep Generative Framework – Behnoush Rezaeianjouybari[1], Ahmed Sherif El-Gizawy[2] ([1,2]*U. of Missouri*)

†Multi-label Prediction in Time Series Datausing Deep Neural Networks – Wenyu Zhang[1], Devesh K. Jha[2], Emil Laftchiev[3], Daniel Nikovski[4] ([1]*Cornell U.;* [2,3,4]*Mitsubishi Electric Research Labs*)

Evaluation of 1D CNN Autoencoders for Lithium-ion Battery Condition Assessment Using Synthetic Data – Christopher J. Valant[1], Jay D. Wheaton[2], Michael G. Thurston[3], Sean P. McConky[4], Nenad G. Nenadic[5] ([1,2,3,4,5]*RIT*)

Paper Session 4C: Predictive Maintenance
Tuesday, 3:15 – 4:45, Room: Pueblo I & II
Session Chair: Daniel Jung (Linkoping University)

Automating Visual Inspection with Convolutional Neural Networks – Sreerupa Das[1], Christopher D Hollander[2], Suraiya Suliman[3] ([1,2,3]*Lockheed Martin*)

Categorization Errors for Data Entry in Maintenance Work-Orders – Thurston Sexton[1], Melinda Hodkiewicz[2], Michael P. Brundage[3] ([1,3]*NIST;* [2]*U. of Western Australia*)

Agreement Behavior of Isolated Annotators for Maintenance Work-Order Data Mining – Emily Hastings[1], Thurston Sexton[2], Michael P. Brundage[3], Melinda Hodkiewicz[4] ([1]*U. of Illinois;* [2,3]*NIST;* [4]*U. of Western Australia*)

†Invited papers concurrently published in IJPHM (www.ijphm.org)

Wednesday, September 25, 2019							Wednesday, September 25, 2019			
Location / Time	Technical Paper Sessions			Tutorial Sessions	Career Fair		Panel Sessions	Technology Demos & Product Showcases		Location / Time
	Arizona II	Arizona III	Pueblo I & II	Apache I	Apache II		Arizona I	Apache III	Apache IV	
7AM – 5PM	Registration			Location: Pueblo III			Registration		Location: Pueblo III	7AM – 5PM
7:00 – 8:00	Continental Breakfast			Location: Grand Coronado I – III			Continental Breakfast		Location: Grand Coronado I – III	7:00 – 8:00
8:00 – 8:50	Opening Remarks Location: Grand Coronado I – III **Luminary Speaker: Victor Baker (*University of Arizona*)** **"The Sciences of Global Megaflooding, Paleoflood Hydrology, and Modern Flood Risks"**						Opening Remarks Location: Grand Coronado I – III **Luminary Speaker: Victor Baker (*University of Arizona*)** **"The Sciences of Global Megaflooding, Paleoflood Hydrology, and Modern Flood Risks"**			8:00 – 8:50
8:50 – 9:00	Break			Location: Grand Coronado IV & V			Break		Location: Grand Coronado IV & V	8:50 – 9:00
9:00 – 10:30	Paper Session 5A: **Deep Networks for PHM**	Paper Session 5B: **Diagnostics II**	Paper Session 5C: **Prognostics II**	Tutorial Session 2: **Uncertainty Management for PHM** Shankar Sankararaman (*PwC*)	Career Fair: General Session 2 **TBD** (see page TBD for details)		Panel Session 5: **PHM for Human Health and Performance** Thurmon Lockhart (*Arizona State University*)	Product Showcases **NIST, PTC, Siemens, QSI, GE, SAE ITC, Gastops, GPMS**	Location: Grand Coronado I – III	9:00 – 10:30
10:30 – 10:45	Break			Location: Grand Coronado IV & V			Break		Location: Grand Coronado IV & V	10:30 – 10:45
10:45 – 12:15	Paper Session 6A: **PHM Application - UAV**	Paper Session 6B: **Performance and Uncertainty**	Paper Session 6C: **Features and Information Fusion**	Private Event (Locaion: Apache I)	Career Fair Follow-up Discussions 4 **TBD**		Panel Session 6: **Precision Agriculture** Alice Robinson (*Karrott Reserach*)	Tech Demo 5 **Testability Engineering And Maintenance System (TEAMS) Toolset** *QSI*	*Reserved*	10:45 – 12:15
12:15 – 1:30	Conference Lunch Location: Grand Coronado I – III **Keynote Speaker: Jon Dunsdon (*GE Aviation Digital*)** **"Advancements in Asset Health Monitoring using AI"**						Conference Lunch Location: Grand Coronado I – III **Keynote Speaker: Jon Dunsdon (*GE Aviation Digital*)** **"Advancements in Asset Health Monitoring using AI"**			12:15 – 1:30
1:30 – 3:00	Paper Session 7A: **Data-driven Prognostics II**	Invited Paper Session 7B: **PHM for Human Health & Performance I**	Invited Paper Session 7C: **Data Challenge Winners**	*Reserved*	Career Fair Follow-up Discussions 5 **TBD**		Panel Session 7: **PHM Enablers for Autonomous Systems** Karl Reichard (*Pennsylvania State University*) and George Vachtsevanos (*Georgia Tech*)	*Reserved*	Tech Demo 6: **AI Assisted Borescope Inspections** *GE*	1:30 – 3:00
3:00 – 3:15	Break			Location: Grand Coronado IV & V			Break		Location: Grand Coronado IV & V	3:00 – 3:15
3:15 – 4:45	Paper Session 8A: **Optimization & Control for PHM**	IJPHM Paper Session 8B: **PHM for Human Health & Performance II**	Invited Paper Session 8C: **Data Challenge Discussion Forum**	*Reserved*	Career Fair Follow-up Discussions 6 **TBD**		Panel Session 8: **Fielded Systems: Lessons Learned** Andy Hess (*The Hess PHM Group*) and Ash Thakker (*Global Technology Connections, Inc.*)	Tech Demo 7: **Health-Ready Components and Systems / ExchangeWell Digital Data Marketplace** *SAE ITC*	*Reserved*	3:15 – 4:45
4:45 – 5:30	Free Time						Free Time			4:45 – 5:30
5:30 – 10:00	Conference Banquet Location: Desert Botanical Garden Buses Begin loading at 5:30PM						Conference Banquet Location: Desert Botanical Garden Buses Begin loading at 5:30PM			5:30 – 10:00

Paper Session 5A: Deep Networks for PHM
Wednesday, 9:00 – 10:30, Room: Arizona II
Session Chair: Gabriel Michau (ETH Zürich)

Rolling Element Bearing Fault Diagnosis Based on with Deep Belief Network and Principal Component Analysis – Guangxing Niu[1], Bin Zhang[2], Paul Ziehl[3], Frank Ferrese[4], Michael Golda[5] ([1,2,3]*U. of South Carolina;* [4,5]*NSWC*)

Health Monitoring Framework for Aircraft Engine System using Deep Neural Network – Hyunseong Lee[1], Guoyi Li[2], Ashwin Rai[3], Aditi Chattopadhyay[4] ([1,2,3,4]*Arizona State U.*)

The Anomaly Detection of 2.4L Diesel Engine Using One-Class SVM with Autoencoder – Gyebong Jang[1], Sung-bae Cho[2] ([1,2]*Yonsei U.*)

Paper Session 5B: Diagnostics II
Wednesday, 9:00 – 10:30, Room: Arizona III
Session Chair: Lou Zhang (MachineMetrics)

Automatic Fault Diagnosis System for Primary Flight Control Actuators – Oliver Ritter[1], Daniele Bruno[2], Rocco Gentile[3], Francesco Marino[4], Antonio Bertolino[5], Andrea Raviola[6], Giovanni Jacazio[7], Massimo Sorli[8] ([1,4]*Lufthansa Technik;* [2,3,5,6,7,8]*Politecnico di Torino*)

Design and In-Water Testing of a Fault-Detection System for Unmanned Underwater Vehicle Actuators – Matt Kemp[1], Jon Erickson[2], Scott Jensen[3], Sotiria Lampoudi[4], Eric J. Martin[5] ([1,2,3,4,5]*Monterey Bay Aquarium Research Institute*)

Permanent Magnet Synchronous Motor Winding Fault Simulation and Diagnosis – Enhui Liu[1], Guangxing Niu[2], Shijie Tang[3], Bin Zhang[4], Jesse Williams[5], Rodney Martin[6], Craig Moore[7] ([1,2,3,4]*U. of South Carolina;* [5]*GTC;* [6]*NASA Ames;* [7]*NASA Marshall*)

Paper Session 5C: Prognostics II
Wednesday, 9:00 – 10:30, Room: Pueblo I & II
Session Chair: Abhinav Saxena (GE Research)

A Prognostics Model to Predict Brake Rotor Thickness Variation – Hamed Kazemi[1], Xinyu Du[2], Samba Drame[3], Regan Dixon[4], Hossein Sadjadi[5] ([1,2,3,4,5]*GM*)

Accurate Estimation of Battery SOH and RUL Based on a Progressive LSTM with a Time Compensated Entropy Index – Taejun Bak[1], Sukhan Lee[2] ([1,2]*Sungkyunkwan U.*)

Adversarial Campaign Mitigation via ROC-Centric Prognostics – Javier Echauz[1], Keith Kenemer[2], Sarfaraz Hussein[3], Jay Dhaliwal[4], Saurabh Shintre[5], Slawomir Grzonkowski[6], Andrew Gardner[7] ([1,2,3,4,5,6,7]*Symantec*)

Paper Session 6A: PHM Application - UAV
Wednesday, 10:45 – 12:15, Room: Arizona II
Session Chair: Nicholas Propes (NAVAIR)

Real time Diagnostics and Prognostics of UAV Lithium-Polymer Batteries – Nick Eleftheroglou[1], Dimitrios Zarouchas[2], Theodoros Loutas[3], Sina Sharif Mansouri[4], George Georgoulas[5], Petros Karvelis[6], George Nikolakopoulos[7], Rinze Benedictus[8] ([1,2,8]*Delft U. of Technology;* [3,5]*U. of Patras;* [4,6,7]*Lulea U. of Technology*)

An Approach for Uncertainty Quantification And Management Of Unmanned Aerial Vehicle Health – Matteo Corbetta[1], Chetan S. Kulkarni[2] ([1,2]*SGT. Inc, NASA Ames*)

Model-based On-board Decision Making for Autonomous Aircraft – Johann Martin Schumann[1], Nagabhushan Mahadevan[2], Michael Lowry[3], Gabor Karsai[4] ([1]*SGT, Inc., NASA Ames;* [2,4]*Vanderbilt U.;* [3]*NASA Ames*)

Paper Session 6B: Performance and Uncertainty
Wednesday, 10:45 – 12:15, Room: Arizona III
Session Chair: Rahul Soangra (Chapman University)

MCATSS - End-To-End Mobile Cardiopulmonary Tolerance Score System – Shravan Aras[1], Anh Dao[2], Chris Gniady[3], Rinku Skaria[4], Zain Khalpey[5] ([1,2,3,4,5]*U. of Arizona*)

A Comparative Study on Computation of Cumulative Distribution Function in Predicting Time of Failure of Engineering Systems – Gina Katherine Sierra Paez[1], Matthew Daigle[2], Kai Goebel[3] ([1]*SGT, Inc., NASA Ames;* [2]*NIO USA;* [3]*PARC*)

Development of Metrics for Resilience Quantification in Energy Systems – Fellipe Sartori da Silva[1], José Alexandre Matelli[2] ([1,2]*São Paulo State U.*)

Paper Session 6C: Features and Information Fusion
Wednesday, 10:45 – 12:15, Room: Pueblo I & II
Session Chair: Sergio Martin (Luleå University of Technology)

Probabilistic Aging Pipe Strength Estimation Using Multimodality Information Fusion – Jie Chen[1], Yongming Liu[2] ([1,2]*Arizona State U.*)

Improved Fault Detection and Isolation of Small Faults using Multiple Residual Generators and Complex Detection Hypotheses: Case Study of an Electro-Hydraulic Aerospace Actuator – Desham Mitra[1], Pulak Halder[2], Siddhartha Mukhopadhyay[3] ([1,3]*IIT Kharagpur;* [2]*RCI*)

Health Index Generation Based on Compressed Sensing and Logistic Regression for Remaining Useful Life Prediction – Christian Knoebel[1], Daniel Strommenger[2], Johannes Reuter[3], Clemens Guehmann[4] ([1,3]*HTWG Konstanz;* [2,4]*Technische U. Berlin*)

Paper Session 7A: Data-driven Prognostics II
Wednesday, 1:30 – 3:00, Room: Arizona II
Session Chair: Chetan Kulkarni (SGT Inc. @ NASA Ames Research Center)

Operating Condition-Invariant Neural Network-based Prognostics Methods applied on Turbofan Aircraft Engines – Gabriel Duarte Pasa[1], Ivo Paixão de Medeiros[2], Takashi Yoneyama[3] ([1,2]*Embraer;* [3]*Instituto Tecnológico de Aeronáutica*)

Process-Monitoring-for- Quality -- A Model Selection Criterion for Shallow Neural Networks – Carlos A. Escobar[1], Ruben Morales-Menendez[2] ([1]*GM;* [2]*Tecnológico de Monterrey*)

Semi-supervised Constrained Hidden Markov Model Using Multiple Sensors: for Remaining Useful Life Prediction and Optimal Predictive Maintenance – Xinyu Zhao[1], Yunyi Kang[2], Hao Yan[3], Feng Ju[4] ([1,2,3,4]*Arizona State U.*)

Invited Paper Session 7B: PHM for Human Health & Performance I
Wednesday, 1:30 – 3:00, Location: Arizona III
Session Chair: Thurmon Lockhart (Arizona State University)

Prediction Model of Postoperative Cardiac Surgical Outcomes using a Smartphone-based Preoperative Gait and Posture Measures – TBD (*TBD*)

Length of Time-Series Gait Data on Lyapunov Exponent – TBD (*TBD*)

Multimodal Wireless Wearable System for Age-Related Mobility Assessment and Fall Risk Prediction – TBD (*TBD*)

Invited Paper Session 7C: Data Challenge Winners
Wednesday, 1:30 – 3:00, Location: Pueblo I & II
Session Chair: Kurt Doughty (Collins Aerospace)

A Fatigue Crack Length Estimation and Prediction using Trans-fitting with Support Vector Regression – Myeongbaek Youn[1], Yunhan Kim[2], Dongki Lee[3], Minki Cho[4] ([1,2]*Seoul National U.;* [3,4]*LG Electronics*)

A Hybrid Approach of Data-Driven and Physics-based Methods for Estimation and Prediction of Fatigue Crack Growth – Hyeon Bae Kong[1], Soo-Ho Jo[2], Joon Ha Jung[3], Jong M. Ha[4], Yong Chang Shin[5], Heonjun Yoon[6], Kyung Ho Sun[7], Yun-Ho Seo[8], Byung Chul Jeon[9] ([1,2,5,6]*Seoul National U.;* [3,7,8]*Korea Institute of Machinery & Materials;* [4]*Korea Research Institute of Standard and Science;* [9]*Republic of Korea Air Force*)

Ensemble Linear Regression and Paris' Law Based Methods for Structure Fatigue Crack Length Estimation and Prediction Using Ultrasonic Wave Data – Meng Rao[1], Xingkai Yang[2], Dongdong Wei[3], Yuejian Chen[4], Lijun Meng[5], Ming J. Zuo[6] ([1,2,3,4,5,6]*U. of Alberta;* [5]*Jiang Han U.*)

Paper Session 8A: Optimization & Control for PHM
Wednesday, 3:15 – 4:45, Room: Arizona II
Session Chair: Bin Zhang (University of South Carolina)

Lifetime Model Development for Integration in Power Management of HEVs By Terms of Minimizing Fuel Consumption and Battery Degradation – Nejra Beganovic[1], Bedatri Moulik[2], Ahmed Mohamed Ali[3], Dirk Soffker[4] ([1]*Mid-Sweden U.;* [2]*Amity U.;* [3,4]*U. of Duisburg-Essen*)

A State-of-Health-Oriented Power Management Strategy for Multi-Source Electric Vehicles Considering Situation-Based Optimized Solutions in Real-Time – Ahmed Mohamed Ali[1], Bedatri Moulik[2], Nejra Beganovic[3], Dirk Söffker[4] ([1,4]*U. of Duisburg-Essen;* [2]*Amity U.;* [3]*Mid-Sweden U.*)

Progress towards a Framework for Aerospace Vehicle Reasoning (FAVER) – Cordelia Mattuvarkuzhali Ezhilarasu[1], Zakwan Skaf[2], Ian K Jennions[3] ([1,2,3]*Cranfield U.*)

IJPHM Paper Session 8B: PHM for Human Health & Performance II
Wednesday, 3:15 – 4:45, Location: Arizona III
Session Chair: Wolfgang Fink (University of Arizona)

A Transfer Active Learning Framework to Predict Thermal Comfort – Annamalai Natarajan[1], Emil Laftchiev[2] ([1]*Philips Research;* [2]*Mitsubishi Electric Research Labs*)

Dynamic Behavior of Cortisol and Cortisol Metabolites in Human Eccrine Sweat – J. Ray Runyon[1], Min Jia[2], Michael R. Goldstein[3], Perry Skeath[4], Leif Abrell[5], Jon Chorover[6], Esther M. Sternberg[7] ([1,2,3,4,5,6,7]*U. of Arizona*)

Effects of Obesity and Fall Risk on Gait and Posture of Community- Dwelling Older Adults – Thurmon E. Lockhart[1], Christopher W. Frames[2], Rahul Soangra[3], Abraham Lieberman[4] ([1,2]*Arizona State U.;* [2,4]*Barrow Neurological Institute;* [3]*Chapman U.*)

Thursday, September 26, 2019							Thursday, September 26, 2019		
Location / Time	Technical Paper Sessions			Tutorial Sessions		Panel Sessions	Planning Sessions		Location / Time
	Arizona II	Arizona III	Pueblo I & II	Apache I		Arizona I	Apache II		
7AM – 12PM	Registration			Location: Pueblo III		Registration	Location: Pueblo III		7AM – 12PM
7:00 – 8:00	Diversity Outreach Breakfast			Location: Grand Coronado I – III		Diversity Outreach Breakfast	Location: Grand Coronado I – III		7:00 – 8:00
8:00 – 8:50	Opening Remarks **Luminary Speaker: Sergio Santamaria (*Phoenix Suns*)** **"Application of PHM in Sports Analytics"**			Location: Grand Coronado I – III		Opening Remarks **Luminary Speaker: Sergio Santamaria (*Phoenix Suns*)** **"Application of PHM in Sports Analytics"**	Location: Grand Coronado I – III		8:00 – 8:50
8:50 – 9:00	Break			Location: Grand Coronado IV & V		Break	Location: Grand Coronado IV & V		8:50 – 9:00
9:00 – 10:30	Paper Session 9A: **Gearbox Diagnostics**	Paper Session 9B: **Diagnostics III**	Paper Session 9C: **Prognostics III**	Panel Session 9: **Theoretical Aspects of Prognostics** Chetan Kulkarni (*SGT Inc., NASA Ames Research Center*)		Panel Session 10: **PHM19 Education and Professional Development Workshop** Karl Reichard (*Pennsylvania State University*) and Jeff Bird (*TECnos*)	PHM Europe 2020 Turin, Italy Planning Meeting		9:00 – 9:30
10:30 – 10:45	Break			Location: Grand Coronado IV & V		Break Location: Grand Coronado IV & V	PHM 2020 Nashville, TN Planning Meeting		9:30 – 11:00
10:45 – 12:15	Paper Session 10A: **Structural Health Monitoring**	Paper Session 10B: **PHM for Air Traffic Management**	Paper Session 10C: **Accelerated Aging and Simulations**	Tutorial Session 3: **Prognostics and Health Management on the Cloud—An Introduction** José Celaya and Indranil Roychoudhury (*Schlumberger*)		Panel Session 11: **Small Business** Ash Thakker (*Global Technology Connection, Inc.*)	Private Event Location: Pima		11:00 – 3:00
12:15 – 1:30	Lunch on your own – *Enjoy Scottsdale!*					Lunch on your own – *Enjoy Scottsdale!*			
1:30 – 3:00	Paper Session 11A: **System Level Health**	Paper Session 11B: **Taxonomy and Knowledge Mangement for PHM**	Paper Session 11C: **PHM for Manufacturing**	*Reserved*		*Reserved*			
3:00 – 3:15	Break			Location: Grand Coronado IV & V		Break	Location: Grand Coronado IV & V		3:00 – 3:15
3:15 – 4:45	*Reserved*	*Reserved*	*Reserved*	*Reserved*		Panel Session 12: **Standards for the Digital Stage** Jeff Bird (*TECnos*) and Brian Weiss (*NIST*)	*Reserved*		3:15 – 4:45
4:45 – 5:00	Closing Remarks			Location: Arizona I		Closing Remarks	Location: Arizona I		4:45 – 5:00

Paper Session 9A: Gearbox Diagnostics
Thursday, 9:00 – 10:30, Room: Arizona II
Session Chair: Melinda Hodkiewicz (UWA)

A Comprehensive Analysis of the Performance of Gear Fault Detection Algorithms – Eric Bechhoefer[1], Brent Butterworth[2] ([1]*GPMS;* [2]*Garmin International*)

An Evaluation of Empirical Approach for Gearbox Diagnosis in the Construction Equipment – Keon Kim[1] ([1]*Doosan Infracore, Ltd*)

Tooth Crack Severity Assessment in the Early Stage of Crack Propagation Using Gearbox Dynamic Model – Xingkai Yang[1], Ming J. Zuo[2], Zhigang (Will) Tian[3] ([1,2,3]*U. of Alberta*)

Paper Session 9B: Diagnostics III
Thursday, 9:00 – 10:30, Room: Arizona III
Session Chair: Felipe Viana (Uptake)

Fault Identification and Isolation in Dynamic Systems Using Multiple Models – Olivia Maria Alves Coelho[1], Wlamir O. L. Vianna[2], Takashi Yoneyama[3] ([1,2]*Embraer;* [3]*Instituto Tecnológico de Aeronáutica*)

Classification Based Diagnosis:: Integrating Partial Knowledge of the Physical System – Ion Matei[1], Johan de Kleer[2], Alexander Feldman[3], Maksym Zhenirovskyy[4], Rahul Rai[5] ([1,2,3,4]*PARC;* [5]*U. at Buffalo - SUNY*)

A Hybrid Qualitative and Quantitative Diagnosis Approach – Ion Matei[1], Maksym Zhenirovskyy[2], Johan de Kleer[3], Alexander Feldman[4] ([1,2,3,4]*PARC*)

Paper Session 9C: Prognostics III
Thursday, 9:00 – 10:30, Room: Pueblo I & II
Session Chair: Matteo Corbetta (SGT Inc., NASA Ames Research Center)

Continuous Times Bayesian Networks in Prognosis and Health Management of Centrifugal Pumps – Tyler Forrester[1], Mark Harris[2], Jacob Senecal[3], John Sheppard[4] ([1,2,3,4]*Montana State U.*)

A Prognostics Framework for Power Semiconductor IGBT Modules through Monitoring of the On-State Voltage – Nicolas Degrenne[1], Chihiro Kawahara[2], Stefan Mollov[3] ([1,2,3]*MERCE*)

[†]Invited papers concurrently published in IJPHM (www.ijphm.org)

[†]TBD IJPHM Paper

Paper Session 10A: Structural Health Monitoring
Thursday, 10:45 – 12:15, Room: Arizona II
Session Chair: Xinyu Du (General Motors)

Chemometrics as a Tool to Gain Insight into Fiber Rope Aging from Infrared Images – Ellen Marie Nordgård-Hansen[1], Håkon Jarle Hassel[2], Rune Schlanbusch[3] ([1,3]*NORCE;* [2]*Idletechs*)

Experimental Results of Acoustic Emission Attenuation Due toWave Propagation in Composites – Sebastian Felix Wirtz[1], Stefan Bach[2], Dirk Söffker[3] ([1,2,3]*U. Duisburg-Essen*)

Isolation-based feature Selection for Unsupervised Outlier Detection – Qibo Yang[1], Jaskaran Singh[2], Jay Lee[3] ([1,2,3]*U. of Cincinnati*)

Paper Session 10B: PHM for Air Traffic Management
Thursday, 10:45 – 12:15, Room: Arizona III
Session Chair: Dirk Soeffker (University of Duisburg-Essen)

A Survey of Flight Crew Procedural Deviation using Anomaly Detection – Vivian Rowoli Igenewari[1], Zakwan Skaf[2], Ian K. Jennions[3] ([1,2,3]*Cranfield U.*)

Risk-Based Dynamic Anisotropic Operational Safety Bound for Rotary UAV Traffic Control – Jueming Hu[1], Heinz Erzberger[2], Kai Goebel[3], Yongming Liu[4] ([1,4]*Arizona State U.;* [2]*U. of California;* [3]*Luleå Technical U.*)

Sptio-temporal Anomaly Detection, Diagnostics, and Prediction of the Air-traffic Trajectory Deviation using the Convective Weather – Xinyu Zhao[1], Hao Yan[2], Jing Li[3], Yutian Pang[4], Yongming Liu[5] ([1,2,3,4,5]*Arizona State U.*)

Paper Session 10C: Accelerated Aging and Simulations
Thursday, 10:45 – 12:15, Room: Pueblo I & II
Session Chair: Jamie Coble (University Of Tennessee, Nuclear Engineering)

A Regularized Deep Clustering Method for Fault Trend Analysis – Yongzhi Qu[1], Yue Zhang[2], David He[3], Miao He[4], Dude Zhou[5] ([1,2,3,4,5]*U. of Illinois at Chicago*)

A Simulation Engine for the Characterization of Capacity Degradation Processes in Lithium-ion Batteries Undergoing Heterogeneous Operating Conditions – Aramis Perez[1], Heraldo Rozas[2], Francisco Jaramillo[3], Vanessa Quintero[4], Marcos Orchard[5] ([1,2,3,5]*U. of Chile;* [4]*U. Tecnológico de Panama*)

Performance of Photovoltaic Modules After an Accelerated Thermal Cycling Degradation Test – Aramis Perez[1], Luis Gabriel Marin[2], Fernando Fuentes[3], Patricio Mendoza[4], Guillermo Jimenez[5], Marcos Orchard[6] ([1,3,4,6]*U. of Chile;* [2]*Cycle System;* [5]*U. de Los Andes*)

Paper Session 11A: System Level Health
Thursday, 1:30 – 3:00, Room: Arizona II
Session Chair: Shuangwen Sheng (National Renewable Energy Laboratory)

Advanced Fault-tolerant Control Strategy of Wind Turbine Based on Squirrel Cage Induction Generator with Rotor Bar Defects – Boubakeur Roubah[1], Houari Toubakh[2], Moamar Sayed-Mouchaweh[3] ([1]*Ferhat Abbas U.;* [2]*Kasdi Merbah U.;* [3]*Mines-Douai*)

Probabilistic Health and Mission Readiness Assessment at System-Level – Leonardo Barbini[1], Michael Borth[2] ([1,2]*TNO*)

Introducing AnomDB: An Unsupervised Anomaly Detection Method for CNC Machine Control Data – Lou Zhang[1], Sarah Elghazoly[2], Brock Tweedie[3] ([1,2,3]*MachineMetrics*)

Paper Session 11B: Taxonomy and Knowledge Mangement for PHM
Thursday, 1:30 – 3:00, Room: Arizona III
Session Chair: Daniel Vissolo (Schlumberger)

Studies to Predict Maintenance Time Duration and Important Factors From Maintenance Workorder Data – Madhusudanan Navinchandran[1], Michael E. Sharp[2], Michael P. Brundage[3], Thurston B. Sexton[4] ([1,2,3,4]*NIST*)

Towards an Enhanced Data- and Knowledge Management Capability: A Data Life Cycle Model Proposition for Integrated Vehicle Health Management. – Alexslis Maindze[1], Zakwan Skaf[2], Ian Jennions[3] ([1,2,3]*Cranfield U.*)

Data-driven Approach to Equipment Taxonomy Classification – Kittipong Saetia[1], Sarah Lukens[2], Erik Pijcke[3], Xiaohui Hu[4] ([1,2,3,4]*GE*)

Paper Session 11C: PHM for Manufacturing
Thursday, 1:30 – 3:00, Room: Pueblo I & II
Session Chair: Shankar Sankarraraman (Vanderbilt University)

A Deep Learning-Based Method for Cutting Parameter Optimization for Band Saw Machine – Pin Li[1], Jianshe Feng[2], Feng Zhu[3], Hossein Davari[4], Liang-Yu Chen[5], Jay Lee[6] ([1,2,3,4,5,6]*U. of Cincinnati*)

Anomaly Detection and Diagnosis In Manufacturing Systems: A Comparative Study Of Statistical, Machine Learning And Deep Learning Techniques – Kalyani Zope[1], Kuldeep Singh[2], Sri Harsha Nistala[3], Arghya Basak[4], Pradeep Rathore[5], Venkataramana Runkana[6] ([1,2,3,4,5,6]*TCS*)

Process Control Decision Inference, Monitoring, and Execution – Robert Matania[1], Jean-Marie Foret[2], Vicente Camarillo[3], Mark Walker[4] ([1,2,3,4]*D2K Technologies*)

Paper Session 12A: Prediction Methods
Thursday, 3:15 – 4:45, Room: Arizona II
Session Chair: Guangxing Niu (University of South Carolina)

Probability of Detection (POD)-based Metric for Evaluation of Classifiers Used in Driving Behavior Prediction – Daniel Adofo Ameyaw[1], Qi Deng[2], Dirk Söffker[3] ([1,2,3]*U. of Duisburg-Essen*)

Aircraft Trajectory Prediction using LSTM Neural Network with Embedded Convolutional Layer – Yutian Pang[1], Nan Xu[2], Yongming Liu[3] ([1,2,3]*Arizona State U.*)

Paper Session 12C: Anomaly Detection II
Thursday, 3:15 – 4:45, Room: Pueblo I & II
Session Chair: Gregory Vogl (NIST)

Inter-Turn Short-Circuit Failure of PMSM Indicator based on Kalman Filtering in Operational Behavior – Badr Mansouri[1], Hicham Janati Idrissi[2], Audrey Venon[3] ([1,2,3]*SAFRAN*)

Computation Method of Gear Dynamic Response Using Experimental Strain Data and Application in Pitting Fault Analysis – Yongzhi Qu[1], Haoliang Zhang[2], Zechao Wang[3], Zude Zhou[4] ([1,2,3,4]*Wuhan U. of Technology*)

A Hybrid Qualitative and Quantitative Diagnosis Approach – Ion Matei[1], Maksym Zhenirovskyy[2], Johan de Kleer[3], Alexander Feldman[4] ([1,2,3,4]*PARC*)

Career Fair

Tuesday and Wednesday, 9:00 – 5:00
Location: Apache II

Are you still looking for a career opportunity in PHM? The PHM Society can help you to meet your next employer at the Career Fair sessions on September 24–25, 2019!

The PHM Career Fair is an exposition for PHM employers to meet with prospective job seekers. This year the PHM Society is holding a Career Fair within the 11th Annual Conference at Scottsdale, Arizona to enable recruiters and job seekers the opportunity to meet and conduct interviews. Come meet and talk with growing companies hiring in PHM!

Benefits for Recruiters

- Recruiters will have access to a large pool of candidates and early-access to their resumes to narrow down the qualified candidates.
- Recruiters will be onsite to interview and have a face-to-face interaction with the candidates for full-time, part-time and internship positions.
- The career fair is an advertised event and offers employers high visibility and recognition during the conference.
- Recruiters will be able to share a description of their vacancies prior to the conference.

Benefits for Job Seekers

- The career Fair is FREE and OPEN to all registered PHM19 conference participants and recruiters.
- Candidates of all ages, all levels of experience, and all industries are encouraged to attend.
- Candidates can access a description of the available openings and e-mail their resumes prior to the career fair to careerfair@phmconference.org.
- Recruiters will be onsite to conduct on-the-spot interviews for full-time, part-time and internship positions.

Participating Companies

Collins Aerospace • GE

Tuesday, September 24, 2019

9:00 – 10:30	General Session 1: **Collins Aerospace • GE**
10:45 – 12:15	Follow-up Discussions 1:
10:45 – 11:30	**Collins Aerospace**
11:30 – 12:15	**TBD**
1:30 – 3:00	Follow-up Discussions 2:
1:30 – 2:15	**GE**
2:15 – 3:00	**TBD**
3:15 – 4:45	Follow-up Discussions 3:
3:15 – 4:00	**TBD**
4:00 – 4:45	**TBD**

Wednesday, September 25, 2019

9:00 – 10:30	General Session 2: **TBD**
10:45 – 12:15	Follow-up Discussions 4:
10:45 – 11:30	**TBD**
11:30 – 12:15	**TBD**
1:30 – 3:00	Follow-up Discussions 5:
1:30 – 2:15	**TBD**
2:15 – 3:00	**TBD**
3:15 – 4:45	Follow-up Discussions 6:
3:15 – 4:00	**TBD**
4:00 – 4:45	**TBD**

For further details or questions, please contact Abbas Chokor at careerfair@phmconference.org or enquire at the Registration Desk.

Tutorials

One of the unique features of the PHM conferences is **free technical tutorials** on various topics in health management taught by industry experts. As educational events tutorials provide a comprehensive introduction to the state-of-the-art in the tutorial's topic. Proposed tutorials address the interests of a varied audience: beginners, developers, designers, researchers, practitioners, and decision makers who wish to learn a given aspect of prognostic health management. Tutorials will focus both on theoretical aspects as well as industrial applications of prognostics. These tutorials reach a good balance between the topic coverage and its relevance to the community.

Tutorial Session 1: Introduction to Prognostics
Tuesday, 9:00 – 10:30, Location: Apache I
Matteo Corbetta
SGT, NASA Ames Research Center

Abstract: This tutorial will focus on the fundamentals and basic concepts of prognostics and health management, giving emphasis to condition-based approaches. The audience will be introduced to the key elements that compose a prognostic framework, their interaction, uncertainty and effect on the prediction of the system evolution over time. The session will continue with an overview of data-driven and model-based approaches for prognostics, and will also propose two case studies on prognostic and failure prediction written in Python programming language. The participants will have direct access to the Python scripts and will be able to run them on their personal laptop*. The tutorial will summarize the theory behind the two algorithms, and will guide the audience through the code for a thorough understanding, from data preprocessing to output representation.

Note: The examples will require Python 2.6 or later, and libraries NumPy, SciPy, and matplotlib, installed on the machine. In addition, it is recommended to also download scripts and slides at https://www.phmconference.org/tutorials.

Presenter Bio: Matteo Corbetta is a Research Engineer with SGT Inc., at NASA Ames Research Center, Calif. His research activity focuses on developing algorithms for diagnostics, prognostics, and uncertainty quantification for critical engineering assets. His recent works involves applications in autonomous aerial systems, aerial vehicle diagnostic and prognostic, and urban air mobility. Prior to joining NASA, he worked as R&D Condition Monitoring Systems Engineer at Siemens Gamesa Renewable Energy, Denmark, and as a Postdoctoral Researcher at Politecnico di Milano, Italy. He obtained Ph.D., M.Sc., and B.Sc. in mechanical engineering from Politecnico di Milano in 2016, 2012 and 2009.

Tutorial Session 2: Uncertainty Management for PHM
Wednesday, 9:00 – 10:30, Location: Apache I
Shankar Sankararaman
PwC

Abstract: This tutorial will focus on the significance, interpretation, quantification, and management of uncertainty in prognostics, with an emphasis on predicting the remaining useful life of engineering systems and components. Prognostics deals with predicting the future behavior of engineering systems, and is affected by various sources of uncertainty. In order to facilitate meaningful prognostics-based decision-making, it is important to analyze how these sources of uncertainty affect prognostics, and thereby, compute the overall uncertainty in the remaining useful life prediction. However, several state-of-the-art industrial techniques do not consider a systematic approach to the treatment of uncertainty. This tutorial will explain the paramount importance of uncertainty quantification and management in prognostics, focusing both on testing-based life prediction and condition-based prognostics. In particular, the suitability of classical (frequentist) and subjective (Bayesian) approaches to uncertainty will be discussed, and it will be explained that the Bayesian interpretation of uncertainty is more suitable for condition-based prognostics and health monitoring. Numerical examples will be used to demonstrate that uncertainty quantification in remaining useful life prediction needs to be approached as an uncertainty propagation problem that can be solved using a variety of statistical methods. Several uncertainty propagation methods will be explained in detail, through immersive implementation (in Python). Finally, practical challenges pertaining to uncertainty quantification and management in prognostics will also be discussed.

Note: This is a hands-on tutorial. It is recommended to download scripts before the tutorial at https://www.phmconference.org/tutorials.

Presenter Bio: Shankar Sankararaman received a B.S. in civil engineering from the Indian Institute of Technology, Madras, in 2007, and later obtained a Ph.D. in civil engineering from Vanderbilt University, Nashville, TN, USA, in 2012. Soon after, he joined NASA Ames Research Center, Moffett Field, CA, where he developed algorithms for system health monitoring, prognostics, decision-making, and uncertainty management. His research focuses on the various aspects of uncertainty quantification, integration, and management in different types of aerospace, mechanical, and civil engineering systems. His research interests include probabilistic methods, risk and reliability analysis, Bayesian networks, system health monitoring, diagnosis and prognosis, decision-making under uncertainty, and multidisciplinary analysis. He is a member of the Non-Deterministic Approaches (NDA) technical committee at the American Institute of Aeronautics, the Probabilistic Methods Technical Committee (PMC) at the American Society of Civil Engineers (ASCE), and the Prognostics and Health Management (PHM) Society. Shankar has co-authored a book on prognostics and published over 100 technical articles in international journals and conferences. Presently, Shankar works as a consultant with PwC where he leads machine learning and predictive analytics efforts for various industrial and business challenges.

Tutorial Session 3: Prognostics and Health Management on the Cloud—An Introduction
Thursday, 10:45 – 12:15, Location: Apache I
Jose Celaya and Indranil Roychoudhury
Schlumberger

Abstract: This tutorial will motivate the use of cloud computing services as a development tool for prognostics applications. It will then cover the implementation of a physics-based prognostics approach on the Google Cloud Platform, and demonstrate how this cloud-friendly PHM approach can be used to predict the Remaining Useful Life (RUL) of an IIoT testbed from the Oil & Gas industry that is representative of a 3-well-pad. Topics covered would be physics-based fault detection, fault isolation, fault identification, and RUL prediction and their 'cloud-friendly' implementation.

Presenter Bios: Indranil Roychoudhury received the B.E. (Hons.) degree in Electrical and Electronics Engineering from Birla Institute of Technology and Science, Pilani, Rajasthan, India in 2004, and the M.S. and Ph.D. degrees in Computer Science from Vanderbilt University, Nashville, Tennessee, USA, in 2006 and 2009, respectively. Currently, Dr. Roychoudhury is an AI Scientist at the Schlumberger Software Technology Innovation Center in Menlo Park, California. Prior to that, he was with SGT, Inc., at NASA Ames Research Center as a Computer Scientist from 2009 - 2018. His research interests include hybrid systems modeling, model-based diagnostics and prognostics, distributed diagnostics and prognostics, and Bayesian diagnostics of complex physical systems. Dr. Roychoudhury is a member of the Prognostics and Health Management Society and a Senior Member of the IEEE.

José R. Celaya is a Principal Scientist and Machine Learning Technical Lead Manager at the Software Technology and Innovation Center, Schlumberger. Previously, he was the Lead Scientist and Co-lead at the Diagnostics and Prognostics Group and a founding member of the Prognostics Center of Excellence, both at the Intelligent Systems Division of NASA Ames Research Center. He received a Ph.D. degree in Decision Sciences and Engineering Systems in 2008, a M. E. degree in Operations Research and Statistics in 2008, a M. S. degree in Electrical Engineering in 2003, all from Rensselaer Polytechnic Institute, Troy New York; and a B. S. in Cybernetics Engineering in 2001 from CETYS University, México.

Panel Sessions

Panel Session 1: PHM for Aviation Maintenance Repair Organizations
Tuesday, 9:00 – 10:30, Location: Arizona I
Session Chairs: Frank Zahiri (USAF Warner Robins ALC) and Andy Hess (The Hess PHM Group)

Description: Maintenance Repair Organizations (MROs) are an extremely critical part of any military or commercial aviation sustainment enterprise. The efficiency and production performance of any MRO directly effects the associated aircraft's fleet-wide operational availability, readiness, sustainment costs. PHM capabilities coupled with Resilient and Smart Manufacturing related technologies can play significant roles in increasing the efficiency and production performance for any aircraft MRO. This panel will explore current MRO challenges and issues; and focus on how particular PHM capabilities and new Resilient and Smart Manufacturing technologies can positively impact MRO performance and the overall goals for the contemporary sustainment enterprise.

Panelists:

- Rob Andes *(TDKC)*
- Daniel Braley *(Boeing)*
- Sudipto Ghoshal *(QSI)*
- Christopher Saldana *(George Institute of Technology)*
- John Semmens *(Lockheed Martin)*

Panel Session 2: PHM for Manufacturing
Tuesday, 10:45 – 12:15, Location: Arizona I
Session Chair: Greg Vogl (NIST)

Description: The future industrial internet of things (IIoT) will realize the connectivity of machine tools and online diagnostics and prognostics for improved product quality and asset utilization. But the question remains: How do we get there? Machine tools are vital for the production of high-value parts, and these machines will still be mechanical in nature, thus subject to wear and performance changes. One vision of IIoT is a future with maintenance systems with self-diagnostic capabilities that enable equipment to achieve and sustain near-zero breakdown performance. Parts should be produced with no unplanned downtime while reducing manufacturing costs and maintaining or increasing part quality. But how to do so? Manufacturers need smart machine tools with online abilities to assess their own health, so that production isn't halted but enhanced. Through identification of current health and early signs of problems, smart machine tools with prognostic and health management (PHM) systems will give manufacturers the trusted information they need to optimize production. Currently, manufacturers are implementing their own PHM programs based around various sensors including MEMS accelerometers. This panel will bring together a diverse group of speakers from industry and academia to discuss online sensor-based solutions to

Want to be a part of next year's PHME2020 Conference (in Turin, Italy) or PHM2020 Conference (in Nashville, Tennessee, USA)? See page 20 for details!

transform machine tools into smart machine tools for the future IIoT. Discussion will focus around sensor-based PHM solutions for spindles and linear axes, which are the main elements of machine tools that affect part quality. However, another goal of the panel is to spur discussion to explore the potential impact of these relatively new approaches to other industries of interest to the PHM Society, such as transportation vehicles and energy production assets.

Panelists:
- Sreerupa ("Rupa") Das *(Lockheed Martin)*
- Jaydeep Karandikar *(GE Global Research)*
- Mark Walker *(D2K Technologies)*
- Lou Zhang *(Machine Metrics)*

Panel Session 3: The Electrifying Pace of Automotive PHM
Tuesday, 1:30 – 3:00, Location: Arizona I
Session Chair: Azeem Sarwar (General Motors)

Description: Increasing electric and electronic content in modern day vehicles is bringing value to the customers but also adding to vehicle complexity. US-based OEMs and suppliers collectively paid about 7.4 billion USD in 2016 for warranty claims – with 50% or more related to electric or electronic components. With increasingly tight emission requirements and growing societal pressures, the auto industry is turning toward electric vehicles. More component sensing is possible than ever before, and more vehicles are boasting 4G connectivity that is essential to off-load data for cloud-based analytics. PHM demands a strategic approach aligned not only with company goals and product requirements but also linked into its field service support. This panel will explore the challenges and opportunities posed by the increasingly electrified automotive market and how PHM technologies can help mitigate warranty costs.

Panelists:
- Regan Dixon *(General Motors)*
- Ravindra Patankar *(KPIT Technologies Limited)*
- Michael Pecht *(CALCE, University of Maryland)*
- Daniel Riegel *(Robert Bosch GmbH)*

Panel Session 4: PHM for Space Applications
Tuesday, 3:15 – 4:45, Location: Arizona I
Session Chairs: Derek DeVries (NGC) and Andy Hess (The Hess PHM Group)

Description: The planned use of manned and long term crewed space platforms, as well as quick to launch and reusable space vehicles, is increasing on a very accelerating rate. After the legacy NASA developed Space Shuttle and LEO ISS; among many things, there are near term NASA plans for: a lunar Gateway station, a permanent lunar base, asteroid present, and Mars bases. Vehicles and platforms to accomplish these far reaching goals will include: crewed space and surface based stations and habitats; various types of launch, long range transportation, and orbit to surface vehicles; and all kinds of support subsystems and technologies. Beside NASA and other government directed organizations; commercial based entities are aggressively developing systems to achieve these same and additional space related goals. These associated commercial focused applications include space tourist to LEO, space based hotels, and resource mining. This panel will focus on issues and challenges associated with these applications; and how PHM capabilities can be applied to reduce risks, increase efficiencies, and ensure resilient sustainment of these vehicles, platforms, habitats, and systems.

Panelists:
- Derek R. DeVries *(NGIS)*
- Terry Haws *(NGIS)*
- James A. Larkin *(Aerojet Rocketdyne)*

Panel Session 5: PHM for Human Health and Performance
Wednesday, 9:00 – 10:30, Location: Arizona I
Session Chairs: Thurmon Lockhart (Arizona State University) and Erica Forzani (Arizona State University)

Description: The age distribution and the mean age are undergoing rapid and significant changes worldwide. Based on current projections made by the United States Census Bureau, the present population of older adults 65 years of age and older will double by the year 2030 and constitute a significant portion of the total population. Considering that three-fourths of Americans age 65 and older have one or more chronic conditions, with nearly 50% of them reporting two or more conditions, the availability of health care resources and health care providers becomes critically important. Many chronic diseases that severely limit quality of life are difficult to manage in their later stages, but can be managed more effectively and efficiently if treated early – as such, underpinnings of Predictive Health Management (PHM) – "predict and render preventive measures prior to failure" is well suited to respond to the health needs of older adults. Implementation of new and innovative approaches to healthcare delivery that focuses on an integrated, yet affordable approach that "closes the gap" between the traditionally separate fields of health monitoring and prevention is necessary. As such, this panel will discuss contributions in the fields of wearable smart sensors, sensor-data-fusion, machine learning and data mining, prediction and diagnosis, and electronic health records and databases - all in the context of prognostics and health management for human health and performance. Moreover, this panel builds on the discussions of the experience and processes encountered/created by the panelists, and highlights specific challenges, needs, and wants with respect to the development and implementation of standards and guidelines pertaining to PHM in the area of human health and performance. This diverse group of panelists will present their perspectives on PHM as it pertains to human assets. Conversations will include PHM's current and future envisioned applications within general healthcare, high stress work environments, sports/athletes, theatre, and space environments, along with how the needs, data stream, and supporting PHM tools, can be better designed, developed, implemented, integrated, verified, and validated to impact the new paradigm of smart healthcare.

Panelists:
- Erica Forzani *(Arizona State University)*
- Liang Dong *(Iowa State University)*
- Thurmon Lockhart *(Arizona State University)*
- Jennifer Margrett *(Iowa State University)*
- Balaji Narashimhan *(Iowa State University)*
- Rahul Soangra *(Chapman University)*
- Teresa Wu *(Arizona State University)*
- Yezhou Yang *(Arizona State University)*

Panel Session 6: Precision Agriculture
Wednesday, 10:45 – 12:15, Location: Arizona I
Session Chair: Alice Robinson (Karrott Reserach)

Description: The objective of our panel is to showcase the exciting world of Precision Agriculture and specifically the emerging revolution in Data-Driven agriculture. Precision Agriculture has been defined by Wikipedia as the key component of the third wave of modern agriculture revolutions. However, despite the many significant advances that have been made in GPS-driven agricultural equipment and the use of in-field sensors and drones for soil and crop monitoring, data-driven, daily farm management still remains a "Holy Grail" to be fully realized. This panel will examine the challenges faced in Big Data acquisition and analysis for rapidly delivering actionable information on a daily basis for supporting complex, farm management decisions.

Panelists:
- David Brown *(Pivot Bio)*
- Eric Johnson *(Airbus)*
- Stan Martin *(ORNL)*

Panel Session 7: PHM Enablers for Autonomous Systems
Wednesday, 1:30 – 3:00, Location: Arizona I
Session Chairs: Karl Reichard (Pennsylvania State University) and George Vachtsevanos (Georgia Tech)

Description: The panel will address PHM and other technologies in the design and operation of unmanned autonomous systems (aerial, ground, sea surface and undersea vehicles). Autonomous systems are attracting the attention of researchers and users in a variety of application domains from Intelligence, Surveillance and Reconnaissance to rescue operations, border patrol, driverless vehicles, driverless air taxis, undersea exploration, among others. It is documented that autonomous systems (UAVs, for example) are failing at alarming rates. PHM and related technologies aim to introduce new tools/methods for their resilient design and safe operation. The panel is inviting the participation of scientists/engineers, students and academics, company personnel, government personnel involved in autonomy and autonomous systems, conference participants interested to learn about the emerging autonomous systems technologies. Panel members and panel participants will discuss current and future technologies for improved system performance. Actual case studies and examples will be used to illustrate the technological innovations.

Panelists:
- Yao Cui *(Kuka Robotics)*
- Wolfgang Fink *(University of Arizona)*
- Kai Goebel *(PARC)*
- Steve Holland *(General Motors, retired)*
- Mathieu Kemp *(Monterey Bay Aquarium)*

Panel Session 8: Fielded Systems: Lessons Learned
Wednesday, 3:15 – 4:45, Location: Arizona I
Session Chairs: Andy Hess (The Hess PHM Group) and Ash Thakker (Global Technology Connections, Inc.)

Description: Several long-term career practitioners in the fields of PHM and CBM+ will share their experiences, observations, and lessons learned as part of this distinguished panel of experts. Much can be learned from the requirements generation, development, Verification and Validation, implementation, maturation, fielded use, fleet support, and enterprise-wide use of real world PHM systems. Just the development of the individual capabilities that make up a comprehensive and fully integrated PHM system; provides many lessons learned - both good and bad. A recently evolving important focused area will also be explored around the question: "just who really owns the data that these systems produce". These issues need to be discussed, documented, and viewed across the many industry sectors that are fielding PHM systems. Short presentations will be given by all panel participants that describe their particular topic area and experiences within the PHM/CBM+ domains. An open panel discussion will follow to explore some of these identified specific issues and concerns.

Panelists:
- James ("Hoffy") Hofmeister *(Ridgetop Group)*
- Mark Hollins *(NAVAIR)*
- Greg Kacprzynski *(Sikorsky / Lockheed Martin RMS)*
- Piyush Modi *(NVIDIA)*
- Michael Pecht *(CALCE, University of Maryland)*

Panel Session 9: Theoretical Aspects of Prognostics
Thursday, 9:00 – 10:30, Location: Apache I
Session Chair: Chetan Kulkarni (SGT Inc., NASA Ames Research Center)

Description: This session is focused on the development of Theoretical Aspects in Prognostics. In majority of the Prognostic and Health Management applications particle filtering-based algorithms are being implemented as the state-of-the-art. However, PF-based prognosis frameworks have demonstrated their drawbacks when trying to estimate the probability of failure in nonlinear, non-Gaussian systems performing uncertain operating profiles. To overcome this issue, it is first necessary to establish adequate performance metrics for the framework which has been discussed and presented in recent years. It has been observed that not much work has been done on standardizing prognostics definitions as they suffer from ambiguous and inconsistent interpretations.

The session plans to bring together academics and industry experts in the area to discuss about the lack of standards due to varied end-user requirements as well as varying application domains, including aerospace, automotive, nuclear power, electrical etc.

Panelists:
- Marcos Orchard *(Universidad de Chile)*
- Marcos Quiñones *(Vanderbilt University)*
- Bin Zhang *(University of South Carolina)*

Panel Session 10: PHM19 Education and Professional Development Workshop
Thursday, 9:00 – 10:30, Location: Arizona I
Session Chairs: Karl Reichard (Pennsylvania State University) and Jeff Bird (TECnos)

Description: The PHM Society mission emphasizes free and unrestricted access to PHM knowledge, promotion of interdisciplinary and international collaboration in PHM and leading the advancement of PHM as an engineering discipline. 'Products' for PHM education and professional development accessible to the whole community contribute to all of these aims.

The PHM Taxonomy under development offers a common basis for understanding PHM domains, and skill levels and advancement. The PHM Continuing Professional Development Guidelines offer personal and organizational career planning and enhancement for the PHM community as a whole.

This workshop format will validate and advance the scope, content and applications of these two products to serve the widest domains of PHM and its stakeholders. Draft versions of the products will be made available in advance through updates to the existing PHM Society forums.

Panelists:
- Jeff Bird *(PHM Society EPD Committee Chair)*
- Jamie Coble *(University of Tennessee)*
- Harry Julijanto *(Rolls Royce USA)*
- Nancy Madge *(TECnos)*
- George Vachtsevanos *(Georgia Tech)*

Panel Session 11: Small Business
Thursday, 10:45 – 12:15, Location: Arizona I
Session Chair: Ash Thakker (Global Technology Connection, Inc.)

Description: There are a variety of different small business organizations involved in prognostics and health management technology and solutions, and their applications include use cases in both the commercial and government/defense sector. Challenges and successes from small business organizations in this field will be highlighted, including how they engage and collaborate with larger organizations on PHM related projects, whether they focus on a service or product type of business model, and different approaches they use for growing and funding their business. Aspects related to which funding approaches they consider, such as SBIR/government grants, venture capital / investment, among other approaches will also be discussed. Ways forwards on how the PHM Society can involve and engage more small business organizations or include more topics at the conference will also be considered.

Panelists:
- Jason Cullison *(Frontier Technology Inc.)*
- Neil Eklund *(Analatom)*
- Sudipto Ghoshal *(Qualtech Systems Inc.)*
- Manny Nwadiogbu *(Smart Asset Monitoring & Management Systems)*
- Felipe Parages *(Uptake)*

Panel Session 12: Standards for the Digital Stage
Thursday, 3:15 – 4:45, Location: Arizona I
Session Chairs: Jeff Bird (TECnos) and Brian Weiss (NIST)

Description: Every industry associated with the discipline of PHM is undergoing a digital transformation. This is especially so with the automobile sector, but other, more traditional disciplines are not far behind. Most standard-setting organization have taken cognizance of this shift and are responding to it with new documents outlining their approach to dealing with all the new technology. In the mobility sector, SAE International is constituting a number of technical committees to deal with digital transformation and to develop standards related to different aspects of the phenomenon. Digital communications and interoperability, Blockchain, Model-based design and testing, Artificial intelligence in

safety critical systems, etc., are some of the topics being considered. Other organizations such as the A4A, IATA, IEEE, and ASTM are also developing standards in this area. This panel will bring together industry experts to discuss the latest progress in these fields.

Panelists:
Steve Holland *(GM Research (retired))*
Logen Johnson *(SAE International)*
Ginger Shao *(Honeywell Aerospace)*

Keynote & Luminary Speakers

Keynote Speaker: Arizona As a Place of Commerce and Business
Tuesday, 8:10 – 8:30
Location: Grand Coronado I – III
Kevin Sullivan
Arizona Commerce Authority

Abstract: TBD

Speaker Bio: Kevin Sullivan brings more than 23 years' experience to the Arizona Commerce Authority. He has spent his career leading and supporting high-performance sales teams primarily within the high technology industry. His experience with both startup (DirecTV, Accrue Software & Good Technology) and large, established global companies in Silicon Valley (SGI, Aspect Communications & Adobe) has provided a wide array of knowledge, which he utilizes to lead the ACA's business attraction efforts.

Mr. Sullivan is a results-driven executive with solid operations management and leadership experience, facilitating strong cross-functional relationships across sales, marketing, finance and legal teams. He consistently builds, motivates and leads teams that have been recognized for their focus on client satisfaction and on the ability to achieve aggressive sales and financial objectives. Mr. Sullivan exhibits a strong record of increasing corporate productivity and achieving results.

Mr. Sullivan holds a Bachelor of Science degree in Business Administration from Saint Mary's College and Juris Doctor from Washburn University.

Keynote Speaker: Lessons Learned in Predictive Analytics for Airline Maintenance Operations
Tuesday, 8:30 – 8:50
Location: Grand Coronado I – III
Josh Melin
Honeywell

Abstract: Honeywell will share lessons learned on its journey to provide improvements in operational interruptions for Airline Operations thru deploying predictive and prescriptive analytics models. While Honeywell has been able to deploy analytics on 5 aircraft types on multiple ATA chapters with around 35% reduction in operation interruption events at a 1% no fault found rate using 100% existing data, the journey didn't come easy. Honeywell will share its lessons learned along the way and some challenges facing the industry that will take the data science community at large to solve.

Speaker Bio: Josh is a Director and the Aero Connected Maintenance Product Owner with Honeywell. He is responsible for managing the strategy, business plan, and P&L for Connected Maintenance. Josh has been with Honeywell over 11 years in positions of increasing responsibility in Engineering, Project Management, Lean, Site Operations Leadership, and Product Line Leadership. Josh holds a Bachelor's of Science Degree in Mechanical Engineering from the Pennsylvania State University and a Master's of Business Administration from Arizona State University.

Keynote Speaker: From the Earth To the Sky: How Bio Fuels and Other Renewable Energy Sources May Impact Global Climate Change and Alter the Course of History
Tuesday, 12:15 – 1:30
Location: Grand Coronado I – III
Stan Martin
Oak Ridge National Laboratory

Abstract: Since the so-called "Neolithic Revolution", when agriculture became a core activity for humanity, humans have wrestled with energy related issues. For the first several millennia, energy was derived primarily from renewable biomass in the form of campfires and cooking fires built from reeds, brush, and woods. Agriculture, transportation, and construction activities were all limited to human and animal power, and this status quo remained relatively unchanged for millennia. The industrial revolution changed all of that as fossil fuels (coal, oil, and gas) came to dominate the energy landscape. The density of energy found in these sources enabled unprecedented advances in prosperity, as humans learned to utilize these sources with ever increasing efficiency in automobiles, tractors, aircraft, and rockets. These advances, which occurred rapidly over the past two centuries, have been ones of unprecedented change that have fundamentally altered our way of life. Within the past two decades, the pace of innovation has increased again due to the coalescence of advances in automation, computerization, and information technology together with an ever increasing understanding of genetics. These advances have conspired to set in motion a series of events which some are calling a "new epoch". The future of humanity in this new epoch will be largely determined by the choices we as nations, corporations, and individuals make. How we use energy is one determinant factor in this equation. Used correctly and wisely, our energy resources have the potential to mitigate the worst effects of climate change, eliminate global hunger, and launch humanity into the stars as a multi-planet species. However, if used unwisely the same tools can be used to exacerbate problems such as inequality, environmental degradation, and pollution resulting in a planet that will be mostly uninhabitable by the end of this century. Here we explore both the promise and the peril of the new energy economy and reflect on how our civilization can "steer the ship" in a meaningful way to ensure a prosperous and hopeful future for humanity.

Speaker Bio: Dr. Stan Martin leads the data management group for the Bio Sciences Division at Oak Ridge National Laboratory (ORNL). Oak Ridge National Laboratory is the largest US Department of Energy science and energy laboratory, conducting basic and applied research to deliver transformative solutions to compelling problems in energy and security. ORNL's diverse capabilities span a broad range of scientific and engineering disciplines, enabling the Laboratory to explore fundamental science challenges and to carry out the research needed to accelerate the delivery of solutions to the marketplace. Stan earned his PhD in Plant Pathology from North Carolina State University where he used neutron scattering, X-ray crystallography, and molecular dynamic simulation techniques to elucidate the mechanisms involved in viral capsid dynamics. Plant virus capsids have been extensively studied as candidate vessels for the delivery of chemotherapeutic agents in cancer research.

Stan has extensive experience in the areas of data analytics, data management, remote sensing, and plant sciences. Stan has also spent a number of years in the genomics space, earning an M.S. in bioinformatics from North Carolina State University. Stan's current research interests include topics related to artificial intelligence in plant sciences, such as the use of unmanned aerial vehicles (UAVs), machine learning, and hyperspectral imaging technology to gather data and make inferences about plant health, and the environmental and management factors that affect plant growth patterns.

Luminary Speaker: The Sciences of Global Megaflooding, Paleoflood Hydrology, and Modern Flood Risks
Wednesday, 8:00 – 8:50
Location: Grand Coronado I – III
Victor Baker
University of Arizona

Abstract: After centuries of geological controversy, it is now well-established that the last major deglaciation of planet Earth, about 16,000 years ago, involved huge outbursts of water from the wasting continental ice sheets, and that this water constituted floods of immense magnitude and relatively short duration. These "megafloods" had short-term peak flows comparable to the more prolonged flows of ocean currents. Recent discoveries have documented more than 40 examples of megaflooding and related immense floods that occurred over vast regions of Asia, Europe, North America, South America, Antarctica, Iceland, and even on the planet Mars. It is becoming increasingly clear that immense outburst floods likely induced very rapid, short-term effects on the planetary environments on both Earth and Mars, greatly altering climates, drainage evolution, and the planetary patterns of water and sediment movement to lakes, seas, and oceans. The Earth megafloods may well have inspired the flood myths that are a part of human cultural heritages around the world.

The study of very ancient megaflooding has led to techniques for studying the kinds of extreme flooding that are increasingly posing hazards to life and property in today's world. The most extreme of these modern floods pose particular risk to nuclear power plants, river dams, and other major infrastructure. The science of "paleoflood hydrology" was initiated by the speaker to provide exact information on the largest flood events that nature can generate. This science is increasingly being used worldwide to estimate the potential flood risks posed by climatic change.

Speaker Bio: Victor R. Baker is Regents' Professor of Hydrology and Atmospheric Sciences, Geosciences, and Planetary Sciences, University of Arizona. He has a B.S. (Geology from Rensselaer Polytechnic Institute in 1967 and a Ph.D. (Geology) from the University of Colorado in 1971. From 1996-2004 he was Department Head of Hydrology and Water Resources (now Hydrology and Atmospheric Sciences), University of Arizona.

Baker has authored or co-authored more than 1000 scientific contributions, including 18 books, 436 research articles and chapters, more than 525 abstracts and short research reports. His research has concerned paleoflood hydrology (a field of study that he defined in the 1970s and 1980s); flood geomorphology; channels, valleys, and geomorphic features on Mars and Venus; catastrophic Pleistocene megaflooding in the northwestern U.S. and central Asia; history/philosophy of Earth and planetary sciences; and the interface of environmental science with public policy. Professor Baker has been President of the Geological Society of America (1998), and among his other honors are Foreign Membership in the Polish Academy of Sciences (1994); Honorary Fellowship in the European Union of Geosciences (1999); the David Linton Award of the British Society for Geomorphology (1995); the Distinguished Scientist Award (2002) and Distinguished Career Award (2010), both from The Geological Society of America Quaternary Geology and Geomorphology Division; the Inaugural International Lectureship of the Geological Society of America (2012-2013), a Fulbright-Hays Senior Research Fellowship (1979-1880); an Indo-American Fellowship (1987-1988); and professional society Fellowships respectively in the American Geophysical Union, the American Association for the Advancement of Science, The Geological Society of America, and the British Society for Geomorphology. His work on megafloods has been featured in multiple television documentaries for PBS, BBC, and the National Geographic, Discovery, and History Channels, including the 2005 NOVA production "Mystery of the Megaflood" and the 2017 NOVA production "Volatile Earth" episode "Killer Floods."

Keynote Speaker: Advancements in Asset Health Monitoring Using AI
Wednesday, 12:15 – 1:30
Location: Grand Coronado I – III
Jon Dunsdon
GE Aviation Digital

Abstract: This talk will focus on application of AI and machine learning technologies in health monitoring of jet engines. Specifically, how AI technologies are pushing the envelope and changing the ways we traditionally thought about PHM. This talk will highlight how Physics based understanding and data driven techniques must come together to drive differentiated outcomes for airline customers. The talk will also present examples on how to combine both structured and unstructured data for predictive maintenance. The presentation will conclude with a section on GE aviation's lessons learnt in this area for the past 7 years.

Speaker Bio: Jon Dunsdon has over 20 years of digital software and services experience with GE, including roles with increasing responsibility across Aviation Systems, Global Research and Aviation. Jon is currently serving as Chief Technology Officer for GE Aviation Digital leading strategy and working with our customers on their Digital Transformations.

Prior to this, Jon served as the Chief Architect for GE Aviation where he led the technical strategy. He has prior experience in data analytics; solution architecture; product definition; and the development of strategic service, product, and technology roadmaps.

Jon holds a degree in Aeronautics and Astronautics (Southampton, UK) and is a Chartered Engineer. He is also an advisor to the UK government on the impact of research across the aerospace industry.

Luminary Speaker: Application of PHM in Sports Analytics
Thurssday, 8:00 – 8:50
Location: Grand Coronado I – III
Sergio Santamaria
Phoenix Suns

Abstract: TBD

Speaker Bio: TBD

Technology Demonstrations

Session Chairs: Jim Larkin (Aerojet Rocketdyne), Laurel Frediani (Sporian Microsystems) and Derek Devries (NGC)

The PHM Society invites our conference sponsors to show off their diagnostic and prognostic engineering approaches through PHM Technology Demonstrations. The concept of the demonstrations is to offer a true "hands-on" learning experience for attendees. Multiple demonstrations will be given as brief tutorials to small groups. Each demo will last 30 to 60 minutes, where attendees will be encouraged to actively participate.

Technology Demonstrations
Tuesday, 9:00 – 4:45, Locations: Apache III & Apache IV
Wednesday, 10:45 – 4:45, Locations: Apache III & Apache IV

Tuesday, September 24, 2019

9:00 – 10:30 Condition Indicator Design & RUL Estimation using MATLAB (Rachel Johnson and Sudheer Nuggehalli, *MathWorks*)
10:45 – 12:15 Connected Ecosystem for Aerospace Intelligence and PHM (Kurt Doughty and Dave Larsen, *Collins Aerospace*)
1:30 – 3:00 TBD (Ginger Shao, *Honeywell*)
3:15 – 4:45 TBD (Justinian Rosca, *Siemens*)

Wednesday, September 25, 2019

10:45 – 12:15 Testability Engineering And Maintenance System (TEAMS) Toolset (Deepak Haste and Sudipto Ghoshal, *QSI*)
1:30 – 3:00 AI Assisted Borescope Inspections (Abhinav Saxena, *GE*)
3:15 – 3:45 Health-Ready Components and Systems /
3:45 – 4:45 ExchangeWell Digital Data Marketplace (Ben Towne, Steve Holland, Leon Gommans, and Drasko Draskovic, *SAE Industry Technologies Consortia*)

Product Showcases

Session Chairs: Jim Larkin (Aerojet Rocketdyne), Laurel Frediani (Sporian Microsystems) and Derek Devries (NGC)

The PHM Society introduces an exciting new type of opportunity for 2019. It is called the Product Showcase, where presenters may take advantage of a unique platform to advertise company products and services in a focused environment. The intent is to generate audience interest for follow-up exchange.

The Product Showcase sessions will be comprised of a series of 10-minute marketing presentations. The communication will be one-way, where all questions/answers are reserved for off-line. Audiences will enjoy this approach as companies strive to make significant first impressions during a condensed window of time.

Product Showcases
Wednesday, 9:00 – 10:30, Location: TBD

Wednesday, September 25, 2019

9:00 – 9:05 *Introduction and Ground Rules*
9:05 – 9:15 Making Maintenance Smarter: NIST Measurement Science to Increase Process and Equipment Reliability (Brian Weiss, *NIST*)
9:15 – 9:25 PTC ThingWorx – The Industrial IoT Platform for PHM (Ian Boulton, *PTC*)
9:25 – 9:35 TBD (Justinian Rosca, *Siemens*)
9:35 – 9:45 Comprehensive Fault Management - the TEAMS way (Sudipto Ghoshal, *QSI*)
9:45 – 9:55 TBD (Abhinav Saxena, *GE*)
9:55 – 10:05 A Registry for Health-Ready Components & Systems and a Digital Data Marketplace For Data They Produce (Ben Towne, *SAE Industry Technologies Consortia*)
10:05 – 10:15 Oil Debris Monitoring – Advanced Techniques for Equipment Health Management (Stephane Daviault, *Gastops*)
10:15 – 10:25 Foresight HUMS: A Prognostic Health Management System for Rotorcraft (Eric Bechhoefer, *GPMS*)
10:25 – 10:30 *Closing Remarks*

Poster Presentations: Tuesday 5:30 – 8:00
Grand Coronado I – III (During Cocktail Reception)

Technical Program Posters
Development of a CPS-Enabled Rehabilitation System for Improved Patient Recovery – Jianshe Feng[1], Pin Li[2], Hossein Davari[3], Jay Lee[4] ([1,2,3,4]*U. of Cincinnati*)
Unsupervised Online Deep Learning Method for Remaining Useful Life Prediction – Yue Zhang[1], Yongzhi Qu[2], David He[3] ([1]*Wuhan U. of Technology;* [2]*U. of Minnesota Duluth;* [3]*U. of Illinois at Chicago*)
Hybrid Fault Prognosis for Excitation Capacitors of Self-Excited Induction Generator for Wind Energy Applications – Massinissa Derbal[1], Houari Toubakh[2], Abdelhamid Bouchachia[3] ([1]*École Nationale Polytechnique;* [2]*Kasdi Merbah U.;* [3]*Bournemouth U.*)
Uncertainty Quantification of Flight Trajectory for Small Unmanned Aerial Vehicles – Portia Banerjee[1], Matteo Corbetta[2] ([1,2]*SGT, Inc., NASA Ames*)
Robust Gear Fault Diagnosis Based on Signal Segmentation and Damage Visualization – Hyung Jun Park[1], Seokgoo Kim[2], Seok-Ju Ham[3], Huh Seok Haeng[4], Joo-Ho Choi[5] ([1,2,3,5]*Korea Aerospace U.;* [4]*LIG Nex1*)
Aircraft APU Prognostic Health Monitoring Utilizing Physics-Based Model – Lukas Palaj[1], Jan Neuzil[2], Heiner Bruns[3] ([1,2,3]*Honeywell*)
Left Ventricular Assist Device Thrombus Detection Using Wavelets and Image Classification – Steven Reuter[1], Ian Prechtl[2], Jason Kolodziej[3], Steven W Day[4] ([1,2,3,4]*RIT*)

Student Posters
TBD – TBD (*TBD*)

Doctoral Symposium Posters
A Physics-based Deep Learning Technique for Prognostics – Khaled Akkad *(University of Illinois–Chicago)*
Vibration-based Condition Monitoring of Industrial Drivetrains Operating under Non-stationary Conditions – Madhurjya Dev Choudhury *(University of Aukland)*
Methodology of Adaptive Prognostics and Health Management Using Streaming Data in Big Data Environment – Jianshe Feng *(University of Cincinnati)*
Multimodality Information Fusion for Aging Pipe Strength and Toughness Estimation Using Bayesian Networks – Jie Chen *(Arizona State University)*
Probabilistic Risk Assessment and Mitigation for UAS Safety and Traffic Management – Jueming Hu *(Arizona State University)*
Adapting Approximate Entropy as a Health Indicator of Rotating Machinery for Estimation of Remaining Useful Life – Cody Walker *(University of Tennessee)*
Novel Waveforms, Models, Algorithms for Cable Health Monitoring – Xuan Wang *(University of South Carolina)*
Deep Learning Enable Diagnostics and Prognostics of Machine Health Condition – Wo Jae Lee *(Purdue University)*
A Framework for Resilience-Informed Decision-Making in Early Design – Daniel Hulse *(Oregon State University)*
A Framework to Interpret Deep Learning-Based Health Management System with Human Interactions – Namkyoung Lee *(University of Maryland)*

Sincere Thanks to All Review Managers and Reviewers

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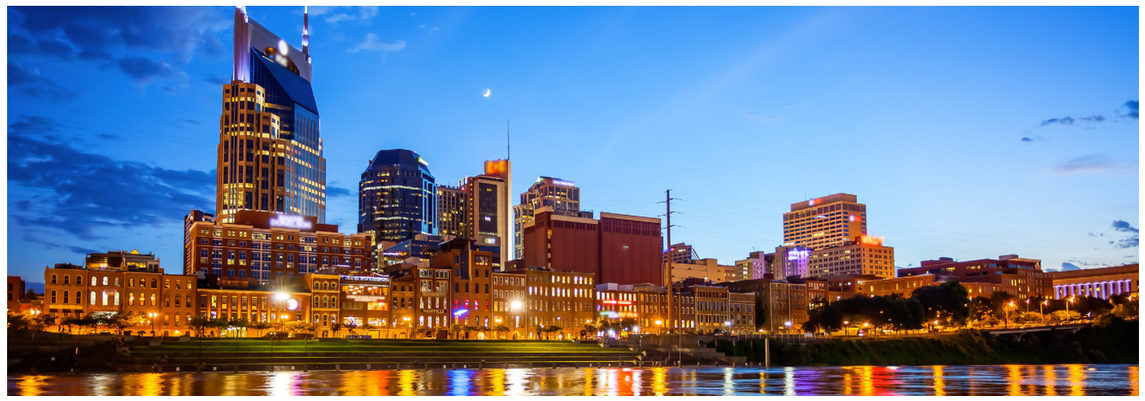
PHMEurope 2020
Turin, Italy, July 1 – 3

Fifth Europe Conference of the Prognostics and Health Management Society
Turin, Italy

Planning Meetings:
Thursday, September 26th
9:00 – 9:30 (PHME2020)
9:30 – 11:00 (PHM2020)
Location: Apache II

Volunteers Needed!

PHM 2020
Nashville, TN, September 28 – October 1



Twelfth Annual Conference of the Prognostics and Health Management Society
Loews Vanderbilt Hotel, Nashville, TN

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Jim Larkin *(Aerojet Rocketdyne)*
Derek Devries *(Northrop Grumman)*

Doctoral Symposium Chairs
Jamie Coble *(University of Tennessee, Knoxville)*
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gastops	Gastops designs and manufactures advanced equipment health monitoring products to ensure that you have real time awareness of the condition of your equipment. With 40 years experience we have developed fleet monitoring and maintenance programs which transform maintenance from the traditional scheduled or reactive maintenance, to a proactive condition-based approach.
GTC Connecting Technology To Business	Global Technology Connections, Inc. has developed next-generation diagnostic/prognostic predictive tools for sustainment of critical plant, equipment and machinery. These innovative CBM/PHM products can substantially reduce the maintenance cost, increase up-time and improve safety in variety of high value assets such as Batteries, Generators, Motors, Pumps, Jet-engines and Turbo-machinery, etc.
GPMS	GPMS offers a next generation Health and Usage Monitoring System for rotorcraft. Their flagship Foresight™ product combines advanced hardware and cloud-based software to provide remote monitoring and predictive maintenance capability. GPMS gives operators the power to "know about it before it breaks, fix it before it matters."
QSI	QSI provides technology for equipment health diagnosis, prognosis and fault management design. QSI's TEAMS® solution identifies failing or failed components, enables dispatch of the right parts, skills and tools, and delivers optimal, context-aware troubleshooting instructions. QSI clients have achieved a threefold reduction in unscheduled downtime and diagnostics part usage.
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NIST National Institute of Standards and Technology U.S. Department of Commerce	The National Institutes of Standards and Technology (NIST), whose mission is to promote U.S. innovation and industrial competitiveness, is actively conducting research in the field of manufacturing PHM, and specifically, delivering test methods, protocols, and tools to increase the reliability and decrease the downtime of smart manufacturing systems and processes.

PHM Society Technical Partners

calce	CALCE – The Center for Advanced Life Cycle Engineering (CALCE) at the University of Maryland is a driving force behind the development and implementation of physics-of-failure (PoF) approaches to reliability, and a world leader in accelerated testing, prognostics and health management (PHM) for electronic systems, electronic part supply-chain management, and sustainment of electronic systems. CALCE consists of over 100 faculty, staff, and students engaged in research with customers that range from military and avionics to automotive, telecom, medical, and consumer electronics. www.calce.umd.edu
COMADEM™	The philosophy of Condition Monitoring and Diagnostic Engineering Management (COMADEM) is: Sustained Prosperity through Proactive Monitoring, Diagnosis, Prognosis and Management of all Assets. Since 1988, refereed annual international congresses and exhibitions have been successfully organized in UK, France, India, Canada, Finland, Australia, USA, Sweden, Portugal, Czech Republic, Spain, Japan, Norway. COMADEM has established and maintained its international reputation as one of the largest and most influential events of its kind. Through the publication of the International Journal of COMADEM, a number of special feature issues dealing with Quality, Reliability and Maintenance, Model-Based Diagnosis, Application of Artificial Intelligence Techniques, Intelligent Materials, Structures and Systems, Performance and Diagnosis of Rotating Machinery Systems and Components, Failure Diagnosis and Prognosis of Swedish Railway Systems, Energy and Environment, Knowledge-based Failure Diagnosis and Prognosis of Engineering Systems, Structural Health Monitoring, Failure Diagnosis and Prognosis of Mining Machinery and Systems and Estimating the Remaining Useful Life (RUL) of Industrial Assets have been published.
COMMERCIAL TECHNOLOGIES FOR MAINTENANCE ACTIVITIES CTMA	Commercial Technologies for Maintenance Activities (CTMA) program, created in 1998, is a joint Department of Defense/National Center for Manufacturing Sciences effort promoting collaborative technology development, demonstration, and transition within DoD. Its objective is to ensure American troops and their equipment are ready to face any situation, with the most up-to-date and best-maintained platforms and tools available. The CTMA program has the ideal collaborative model for manufacturers, academia and DoD. We create relationships and opportunities, drive cutting edge R&D, and conduct industry intelligence from a unique perspective. Through partnerships, training, software, and business operations, CTMA can help achieve industry objectives while satisfying DoD needs through demonstration of new technologies prior to full deployment.
diag21	Diag21 is an association that was created in 2009, at the initiative of a group of industrials Aeronautics and Defence. Its internationally oriented, is dedicated to the optimization of testability, diagnosis and prognosis (PHM) of complex systems in the areas of aerospace, land, car, rail and marine. Close to industry needs, diag21 offers exchange and service platforms.
Helicopter Association International	Established In 1948, the Helicopter Association International (www.rotor.org) is the professional trade association representing the international helicopter community. HAI's membership includes helicopter owners, operators, manufacturers, suppliers, service organizations, pilots, maintenance technicians and students. Its "Mission" is to provide its members with services that directly benefit their operations, and to advance the international helicopter community by providing programs that enhance safety, encourage professionalism and promote the unique contributions vertical flight offers society.
IMS CENTER FOR INTELLIGENT MAINTENANCE SYSTEMS	The IMS Center is a leading NSF Industry/University Cooperative Research Center (I/UCRC) in the area of Prognostics and Health Management (PHM). The Center has over fifteen years of experience in developing and delivering PHM solutions for a wide-range of applications. IMS Center's mission is to enable products and systems to achieve and sustain near-zero breakdown performance, and transform maintenance data to useful information for improved productivity and asset life-cycle utilization. Since its inception, the Center has conducted over 100 successful industry and NSF supported projects, and has attracted over 80 members from all across the globe. The IMS Center was recently identified as the most economically impactful I/UCRC in NSF's recent study titled Measuring the Economic Impacts of the NSF Industry/University Cooperative Research Centers Program: A Feasibility Study. According to this study, the Center delivered its members a $846.7 Million in combined benefits over the last ten years.
Cranfield IVHM Centre BOEING	IVHM Center—the Integrated Vehicle Health Management (IVHM) Centre at Cranfield University in the UK—was established in 2008. It is funded by a number of large companies—Boeing, BAE Systems, Rolls-Royce, Thales and Meggitt—to work on high impact topics. The increasingly important area of IVHM technology informs existing concepts of vehicle maintenance, repair and overhaul by offering a total health check for high-tech, high-value vehicles such as aircraft, ships, high-speed trains and high performance cars.
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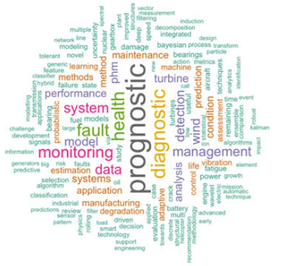

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- Data-Driven & Model-Based Prognostics
- PHM Sensors and Devices
- Fault-Adaptive Control Methods
- Physics of Failure Mechanisms
- Modeling and Simulations
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- Structural Health Management
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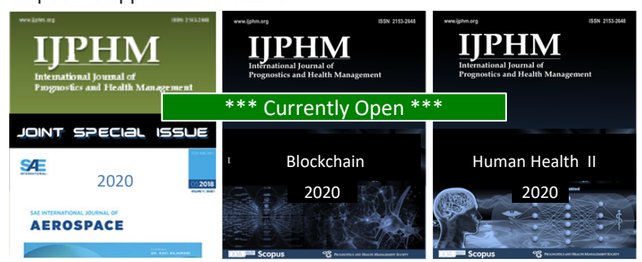
Apart from regular issues, special issues focus on advances in research in condition monitoring applications in specific application domains. CFPs soliciting papers are available from the journal website. A secondary goal is to document and benchmark the state-of-the-art in respective application domains.



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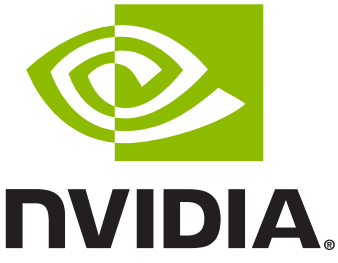
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