



# PHM 2016

8<sup>th</sup> Annual Conference of the  
Prognostics and Health Management Society

Denver, CO

October 3 – 6, 2016



[www.phmconference.org](http://www.phmconference.org)

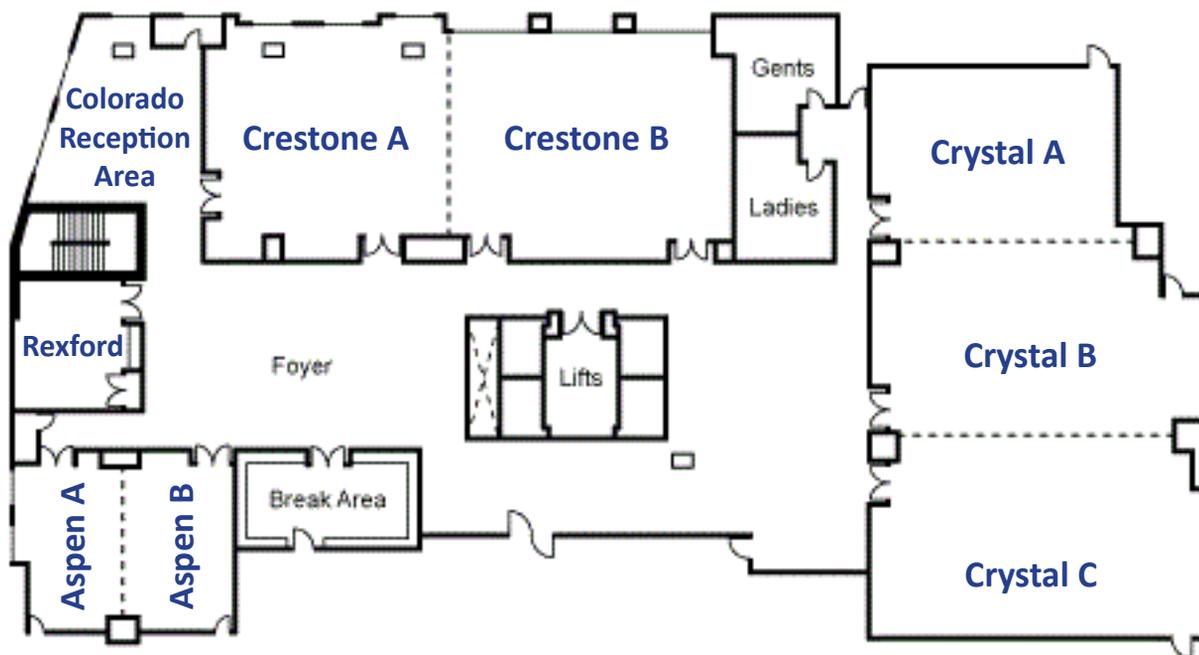


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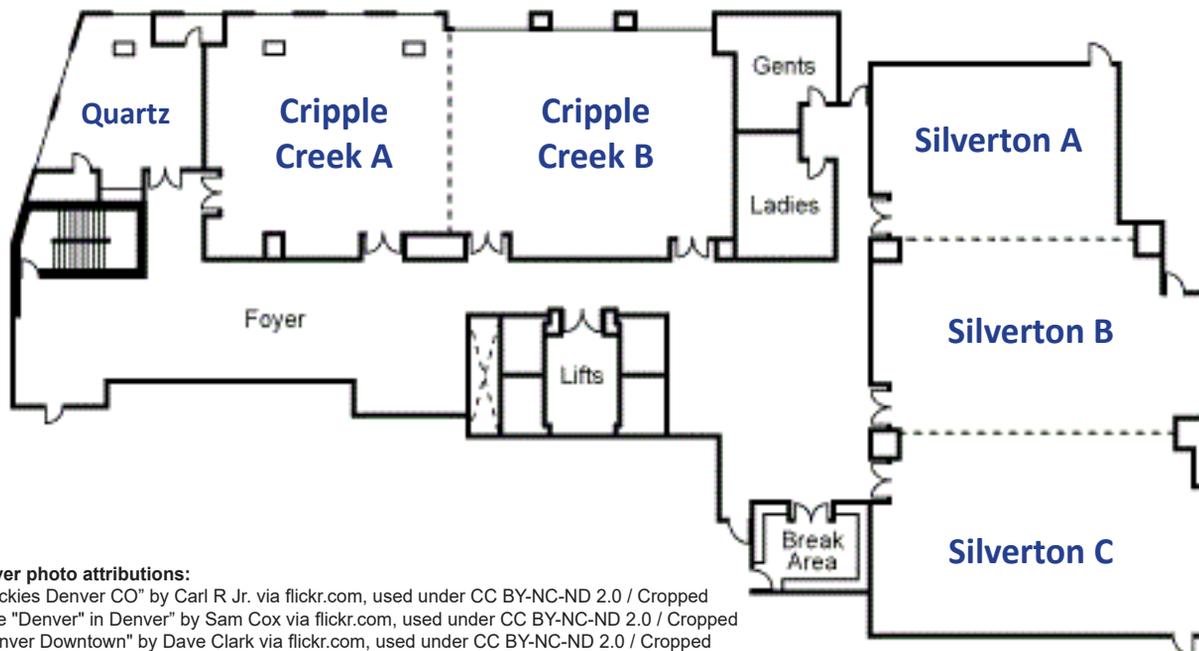
 **phmsociety**

# Embassy Suites Denver Downtown Convention Center

## 3<sup>rd</sup> Floor



## 2<sup>nd</sup> Floor



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## Welcome to Denver!

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Welcome to beautiful Denver, Colorado, for the 2016 Annual Conference of the Prognostics and Health Management Society. This is the 8<sup>th</sup> annual conference of the PHM Society and we are thrilled to be here in Denver. We have an exciting program this year which builds on the success of our previous conferences. Those of you who attended the conference last year in San Diego, California, know that we have big (well small) flip flops to fill. Two years ago we met in Ft. Worth, TX. If you combine Texas and California, flip flops and cowboy boots, you get river sandals and hiking boots, laid back and high adrenaline. Welcome to Colorado.

Denver has world-class museums, unique downtown arts districts, and highly-varied urban architecture to explore. This includes the iconic Union Station, which serves not only as a transportation hub, but as a foodie mecca with a dozen chef-owned restaurants and bars. The 16<sup>th</sup> Street Mall, just two blocks away, is a mile-long pedestrian mall designed by the famous architect I.M. Pei, lined with restaurants and shops, and served by free shuttle busses. Other sites in Denver include the Denver Art Museum, the Museum of Nature and Science, the (Unsinkable) Molly Brown House Museum, the Denver Mint (maybe the easiest way to grow your PHM budget), and many other museums within walking distance of the conference hotel. Downtown Denver is also home to a vast number of craft- and micro-breweries; several, including “Wynkoop” and “Great Divide,” are right downtown and have late-afternoon and evening tours for anyone interested. If you are sticking around for the weekend, Denver is also home to the Great American Beer Festival, right across the street at the Colorado Convention Center this weekend.

The city is also a hub for various sporting activities. Perhaps we will see some of you out for an early-morning run this week! A great location is the Cherry Creek Trail along Cherry Creek just

on the other side of the Convention Center from the hotel. If you prefer two wheels to two feet, you can rent bicycles from Denver B-Cycle kiosks located around town. Denver is also home to several professional sports teams, including the Rockies, Nuggets, Rapids, Spurs (look that one up), and the World Champion Denver Broncos. While the Rockies’ season is over, the Nuggets’ hasn’t started, and the Broncos don’t have a game while we are here, you will get a chance to see and tour Sports Authority Field at Mile High, the Broncos Stadium, where we will have this year’s conference banquet.

Last, but certainly not least, Colorado is a worldwide destination for outdoor enthusiasts. Whether you hike, bike, run, climb, ski, or just enjoy the view, Colorado has just about every type of outdoor attraction you can think of. Colorado is home to Rocky Mountain, Mesa Verde, Black Canyon of the Gunnison, and Great Sand Dunes National Parks, and this year is the 100<sup>th</sup> anniversary of the United States National Park Service. Denver sits on what is known as the front range of the Rockies—this is where the Rocky Mountains start! We are hoping for nice, sunny weather while we are here this week, but it won’t be too long until the mountains to the west are covered with snow and beckoning skiers to come and play.

We hope that you have a great week here at the PHM Conference and also get a chance to explore downtown Denver and possibly even more of Colorado. If not, we’re sure that they would welcome you back. While neither Dave nor Karl are from Colorado, we’ve both enjoyed visiting here in the past and it’s one of our favorite destinations for work and play. We predict that you will have a wonderful time this week.

David Larsen and Karl Reichard

2016 Conference Co-Chairs

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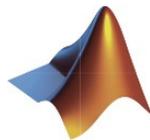
## Come Visit the Following Sponsors (3rd Floor Crystal Ballroom Foyer)

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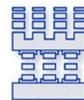
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**Get details of the Conference using the free Whova mobile app on your phone or tablet. See page 4 for details.**

Saturday, October 1, 2016			
Location	PHM Fundamentals Short Course		Location
Time	Crystal Ballroom AB		Time
8AM – 5PM	Registration		8AM – 5PM
	Location: Crystal Ballroom AB		
8:00 – 12:00	PHM Fundamentals Short Course <i>Separate Registration Required</i>		8:00 – 12:00
12:00 – 1:00	Lunch		12:00 – 1:00
1:00 – 5:00	PHM Fundamentals Short Course <i>Separate Registration Required</i>		1:00 – 5:00

Sunday, October 2, 2016			
Location	PHM Fundamentals Short Course	Doctoral Symposium	Location
Time	Crystal Ballroom AB	Aspen AB	Time
12PM – 5PM	Registration		12PM – 5PM
	Location: 3 <sup>rd</sup> Floor Foyer		
8:00 – 12:00	PHM Fundamentals Short Course <i>Separate Registration Required</i>	<i>Reserved for PHM Conference</i>	8:00 – 12:00
12:00 – 1:00	Lunch		
1:00 – 5:00	PHM Fundamentals Short Course <i>Separate Registration Required</i>	Doctoral Symposium	1:00 – 3:00
		Break	3:00 – 3:30
		Doctoral Symposium	3:30 – 5:30
5:00 – 8:30	<i>Reserved for PHM Conference</i>	Doctoral Symposium Dinner	5:30 – 6:30
		Doctoral Symposium	6:30 – 8:30

## Optional Short Course Agenda (See Page 12 for Details)

### Saturday, October 1, 2016

8:00 – 10:20	Session 1:	Crystal Ballroom AB
	<b>Welcome and Introductions</b>	
	<b>Introduction to PHM</b>	
	<b>Deriving Requirements for PHM</b>	
	<b>PHM Performance Metrics</b>	
10:20 – 10:40	Break	
10:40 – 12:00	Session 2:	Crystal Ballroom AB
	<b>Diagnostics Methods</b>	
	<b>Diagnostics Case Studies</b>	
12:00 – 1:00	Lunch (provided)	
1:00 – 3:20	Session 3:	Crystal Ballroom AB
	<b>Prognostics</b>	
	<b>Data Analytics Methods</b>	
	<b>Prognostics Case Studies</b>	
3:20 – 3:40	Break	
3:40 – 5:15	Session 4:	Crystal Ballroom AB
	<b>Sensors and Data Processing</b>	
	<b>Analysis Mini Workshop</b>	
	<b>Summary of Workshop Results</b>	
8:00 – ?	Non-hosted dinner with all participants	

### Sunday, October 2, 2016

8:30 – 10:30	Session 5:	Crystal Ballroom AB
	<b>CBM+ Technologies</b>	
	<b>Cost Benefit Analysis</b>	
	<b>Plenary – Issues and Needs</b>	
10:30 – 10:45	Break	
10:45 – 12:30	Session 6:	Crystal Ballroom AB
	<b>Reliability and Life Cycle Management</b>	
	<b>Fielded Systems Case Studies – 1</b>	
12:30 – 1:30	Lunch (provided with evaluation forms)	
1:30 – 3:20	Session 7:	Crystal Ballroom AB
	<b>Fielded Systems Case Studies – 2</b>	
	<b>Case Study Workshop Introduction</b>	
	<b>Case Study Mini workshop</b>	
3:20 – 3:40	Break	
3:40 – 4:15	Session 8:	Crystal Ballroom AB
	<b>Way Forward</b>	
	<b>Wrap up with Evaluation Forms</b>	

Doctoral Symposium Detail – Sunday, October 2, 2016

1:15 – 1:30	Doctoral Symposium Welcome <i>Jamie Coble</i>
1:30 – 1:40	<b>Presentation #1: Circuit Breaker Health and Reliability Monitoring: The Key to Realizing a Smarter Electricity Grid</b> Payman Dehghanian, <i>Texas A&amp;M University</i>
1:40 – 2:00	Panelist Feedback & Audience Q/A
2:00 – 2:10	<b>Presentation #2: Algorithms for Hybrid Diagnostics of Nonlinear Systems</b> Turki Haj Mohamad, <i>Villanova University</i>
2:10 – 2:30	Panelist Feedback & Audience Q/A
2:30 – 2:40	<b>Presentation #3: Fault-Tolerant Supervisory Control Mechanism for Chiller Plants</b> Khushboo Mittal, <i>University of Connecticut</i>
2:40 – 3:00	Panelist Feedback & Audience Q/A
3:00 – 3:30	Break
3:30 – 3:40	<b>Presentation #4: Bayesian Cramér-Rao Bounds for Time-of-Failure Probability Mass Function Estimation</b> David Acuña, <i>University of Chile</i>
3:40 – 4:00	Panelist Feedback & Audience Q/A
4:00 – 4:10	<b>Presentation #5: Development of Deep Learning Based Approaches for Rotating Machinery Fault Diagnosis with Big Data</b> Miao He, <i>University of Illinois at Chicago</i>
4:10 – 4:30	Panelist Feedback & Audience Q/A
4:30 – 4:40	<b>Presentation #6: Model-Based Failure Prognosis Approach for Complex Systems to Support Asset Management</b> Olivier Blancke, <i>École de Technologie Supérieure</i>
4:40 – 5:00	Panelist Feedback & Audience Q/A
5:00 – 5:10	<b>Presentation #7: Toward Battery Health Management for Small-size Battery-powered Rotary-wing Aircraft</b> Gina Sierra, <i>University of Chile</i>
5:10 – 5:30	Panelist Feedback & Audience Q/A
5:30 – 6:30	Doctoral Symposium Dinner for participants and panelists
6:30 – 6:40	<b>Presentation #8: Deep Learning Based Diagnosis of Journal Bearing Rotor Systems</b> Joon Ha Jung, <i>Seoul National University</i>
6:40 – 7:00	Panelist Feedback & Audience Q/A
7:00 – 7:10	<b>Presentation #9: Probabilistic Pipe Strength and Toughness Estimation through Information Fusion with Bayesian Updating</b> Sonam Dahire, <i>Arizona State University</i>
7:10 – 7:30	Panelist Feedback & Audience Q/A
7:30 – 7:40	<b>Presentation #10: Meta Learning for Fault Tolerant PHM Systems Considering Correlated Failures</b> Saikath Bhattacharya, <i>University of Massachusetts Dartmouth</i>
7:40 – 8:00	Panelist Feedback & Audience Q/A
8:00 – 8:15	Panelists Final Thoughts
8:15 – 8:20	Feedback from Students & Audience
8:20 – 8:30	Conclusions and Feedback

Monday, October 3, 2016

Location Time	Track A: Technical Paper Sessions	Track B: Technical Paper Sessions	Location: 3 <sup>rd</sup> Floor Foyer
	Cripple Creek A	Cripple Creek B	
7AM – 5PM	Registration		
8:00 – 9:45	Tutorial Session 1A: <b>Diagnostics</b> <i>Dr. Matthew Daigle (NASA)</i> <i>Dr. Indranil Roychoudhury (NASA)</i>	Tutorial Session 1B: <b>An Introduction to Data-Driven Prognostics of Engineering Systems</b> <i>Dr. Jamie Coble (Univ of Tennessee)</i>	
9:45 – 10:15	Break		Location: 3 <sup>rd</sup> Floor Foyer
10:15 – 12:00	Tutorial Session 2A: <b>Security Prognostics</b> <i>Dr. Scott Evans (GE Global Research)</i>	Tutorial Session 2B: <b>Big Data Analytics</b> <i>John Patanian (GE Power)</i>	
12:00 – 1:00	Lunch on your own		
1:00 – 1:45	Opening Remarks <b>Opening Keynote: Dr. Jay Lee, University of Cincinnati</b> “Trends and Recent Advances of Industrial Big Data Analytics and Cyber Physical Systems for PHM Applications”		Location: Crystal Ballroom
1:45 – 3:30	Paper Session 1A: <b>Aviation I</b>	Paper Session 1B: <b>Diagnostics I</b>	
3:30 – 3:45	Break		Location: 3 <sup>rd</sup> Floor Foyer
3:45 – 5:30	Paper Session 2A: <b>Systems I</b>	Paper Session 2B: <b>Features I</b>	
5:30 – 7:30	Opening Welcome Reception		Location: Crystal Ballroom Foyer

## The Conference

The Prognostics and Health Management Society (PHM Society) welcomes you to its annual international conference. As the Society's annual flagship event, the 2016 PHM Conference brings together the global community of PHM experts from industry, academia, and government in diverse application areas such as smart manufacturing, wind energy, oil and gas, aerospace, transportation, automotive, and industrial automation. The conference features keynote and luminary presentations, invited panel sessions, technology demonstrations, a data challenge, a special session for Human Assets, a doctoral symposium, tutorials free to all registrants, a dedicated poster session during planned social hours, a Job Fair, and a two-day intensive short course on PHM fundamentals in conjunction with the conference. Several social events will provide opportunities for participants to connect with colleagues.



## 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, physics, 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.

## What Sets This Conference Apart

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. 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.

## 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 **PHM2016** event and passcode **phmsociety**, if prompted.



Track C: Panel Sessions		Track D: Technology Demos		Location
Crestone A		Aspen AB		Time
Registration		Registration		Location: 3 <sup>rd</sup> Floor Foyer
Reserved for PHM Conference		Reserved for PHM Conference		7AM – 5PM
Reserved for PHM Conference		Reserved for PHM Conference		8:00 – 9:45
Break		Break		Location: 3 <sup>rd</sup> Floor Foyer
Reserved for PHM Conference		Reserved for PHM Conference		9:45 – 10:15
Reserved for PHM Conference		Reserved for PHM Conference		10:15 – 12:00
Lunch on your own		Lunch on your own		12:00 – 1:00
Opening Remarks		Opening Remarks		Location: Crystal Ballroom
<b>Opening Keynote: Dr. Jay Lee, University of Cincinnati</b> “Trends and Recent Advances of Industrial Big Data Analytics and Cyber Physical Systems for PHM Applications”				1:00 – 1:45
Panel Session 1: <b>PHM For Human Assets I</b> <i>Wolfgang Fink (University of Arizona)</i>		Reserved for PHM Technology Demonstration Setup		1:45 – 3:30
Break		Break		Location: 3 <sup>rd</sup> Floor Foyer
Panel Session 1 (cont'd): <b>PHM For Human Assets II</b> <i>Wolfgang Fink (University of Arizona)</i>		Reserved for PHM Technology Demonstration Setup		3:30 – 3:45
Break		Break		Location: 3 <sup>rd</sup> Floor Foyer
Panel Session 1 (cont'd): <b>PHM For Human Assets II</b> <i>Wolfgang Fink (University of Arizona)</i>		Reserved for PHM Technology Demonstration Setup		3:45 – 5:30
Opening Welcome Reception		Opening Welcome Reception		Location: Crystal Ballroom Foyer
				5:30 – 7:30

**Paper Session 1A: Aviation I**

Monday, 1:45 – 3:30, Room: Cripple Creek A

Session Chair: Rhonda Whaltheal — UTAS

Improved Time-Based Maintenance in Aeronautics with Linear Support Vector Machines — Marcia Baptista<sup>1</sup>, Ivo P. de Medeiros<sup>2</sup>, Joao P. Malere<sup>3</sup>, Helmut Prendinger<sup>4</sup>, Cairo L. Nascimento Jr.<sup>5</sup>, Elsa Henriques<sup>6</sup> (<sup>1,6</sup>Universidade de Lisboa, Portugal; <sup>2,3</sup>Embraer SA, Brazil; <sup>4</sup>National Institute of Informatics, Japan)

Flight Anomaly Tracking for Improved Situational Awareness: Case Study of Germanwings Flight 9525 — Murat Yasar<sup>1</sup> (<sup>1</sup>United Technologies Research Center)

Anomaly Detection and Fault Disambiguation in Large Flight Data: A Multi-modal Deep Auto-encoder Approach — Kishore K. Reddy<sup>1</sup>, Soumalya Sarkar<sup>2</sup>, Vivek Venugopalan<sup>3</sup>, Michael Giering<sup>4</sup> (<sup>1,2,3,4</sup>United Technologies Research Center)

**Paper Session 1B: Diagnostics I**

Monday, 1:45 – 3:30, Room: Cripple Creek B

Session Chair: Abhinav Saxena — NASA

Solenoid Valve Fault Diagnosis for Urban Railway Braking Systems with Physical Model and Embedded Sensor Signals — Boseong Seo<sup>1</sup>, Sooho Jo<sup>2</sup>, Hyunseok Oh<sup>3</sup>, Byeng D. Youn<sup>4</sup> (<sup>1,2,3,4</sup>Seoul National University, Republic of Korea)

Spur Gear Electrical Pitting Wear Diagnostic from Tribological Responses — Surapol Raadnu<sup>1</sup> (<sup>1</sup>King Mongkut's University of Technology North Bangkok, Thailand)

Integration of failure assessments into the diagnostic process — Roxane Koitz<sup>1</sup>, Franz Wotawa<sup>2</sup> (<sup>1,2</sup>Institute for Software Technology, Austria)

**Paper Session 2A: Systems I**

Monday, 3:45 – 5:30, Room: Cripple Creek A

Session Chair: Kirtland McKenna — Colorado School of Mines

Autonomous Operations System: Development and Application — Jaime A. Toro Medina<sup>1</sup>, Kim N. Wilkins<sup>2</sup>, Mark Walker<sup>3</sup>, Gerald M. Stahl<sup>4</sup> (<sup>1,4</sup>NASA Kennedy Space Center; <sup>2</sup>General Atomics; <sup>3</sup>D2K Technologies)

Distributed Real Time Compressor Blade Health Monitoring System — Lijie Yu<sup>1</sup>, Sachin Srivastava<sup>2</sup> (<sup>1</sup>GE Power Services Engineering, USA; <sup>2</sup>GE Power Services Engineering, India)

An Architectural Framework for Reliability Centered Maintenance and Remote Maintenance Monitoring of Complex Distributed Systems — Henry Silcock<sup>1</sup>, Becky Norman<sup>2</sup>, Jason Ricles<sup>3</sup> (<sup>1,2,3</sup>Mikros Systems Corporation)

**Paper Session 2B: Features I**

Monday, 3:45 – 5:30, Room: Cripple Creek B

Session Chair: Ravi Rajamani — drR<sup>2</sup> Consulting

Leakage Detection of Steam Boiler Tube in Thermal Power Plant Using Principal Component Analysis — Jungwon Yu<sup>1</sup>, Jaeyel Jang<sup>2</sup>, Jaeyeong Yoo<sup>3</sup>, June Ho Park<sup>4</sup>, Sungshin Kim<sup>5</sup> (<sup>1,4,5</sup>Pusan National University, South Korea; <sup>2</sup>Korea East-West Power Co., Ltd., South Korea; <sup>3</sup>XEONET Co., Ltd., South Korea)

An Overview of Useful Data Sources and Techniques for Improved Multivariate Diagnostics and Prognostics in Condition-Based Maintenance — Carolin Wagner<sup>1</sup>, Philipp Saalman<sup>2</sup>, Bernd Hellingrath<sup>3</sup> (<sup>1,2,3</sup>Westfälische Wilhelms-Universität Münster, Germany)



Tuesday, October 4, 2016

Location Time	Track A: Technical Paper Sessions	Track B: Technical Paper Sessions	
	Cripple Creek A	Cripple Creek B	
7AM – 5PM	Registration		Location: 3 <sup>rd</sup> Floor Foyer
7:45 – 8:00	Continental Breakfast		Location: 3 <sup>rd</sup> Floor Foyer
8:00 – 8:45	<b>Luminary Presentation: Dr. David Hilmers, former Astronaut, Baylor College of Medicine</b> “Dealing with Disaster in Space and on Earth”		Location: Crystal Ballroom
8:45 – 10:15	Paper Session 3A: <b>Prognostics I</b>	Paper Session 3B: <b>Turbines</b>	
10:15 – 10:30	Break		Location: 3 <sup>rd</sup> Floor Foyer
10:30 – 12:00	Paper Session 4A: <b>Data Challenge Winners</b>	Paper Session 4B: <b>Diagnostics II</b>	
12:00 – 1:15	Conference Lunch <b>Keynote Speaker: Rhonda Whalhall, United Technologies Aerospace Systems</b> “The Role of PHM at Commercial Airlines”		Location: Crystal Ballroom
1:15 – 3:00	Paper Session 5A: <b>Industrial &amp; Manufacturing Applications I</b>	Paper Session 5B: <b>Features II</b>	
3:00 – 3:30	Break		Location: 3 <sup>rd</sup> Floor Foyer
3:30 – 5:15	Paper Session 6A: <b>Aviation II</b>	Paper Session 6B: <b>Batteries I</b>	
5:15 – 7:30	Poster Reception		Location: Crystal Ballroom

**Paper Session 3A: Prognostics I**

Tuesday, 8:45 – 10:15, Room: Cripple Creek A

Session Chair: Kai Goebel — NASA Ames

<sup>†</sup>An Inference-based Prognostic Framework for Health Management of Automotive Systems — Chaitanya Sankavaram<sup>1</sup>, Anuradha Kodali<sup>2</sup>, Krishna Pattipati<sup>3</sup>, Satnam Singh<sup>4</sup>, Yilu Zhang<sup>5, 6</sup> (<sup>1,2,3</sup>University of Connecticut; <sup>2</sup>University of California Santa Cruz, NASA Ames Research Center; <sup>4</sup>CA Technologies, GM India Science Lab, India)

PHM Decision Support Under Uncertainty — Murat Yasar<sup>1</sup>, Teems Lovett<sup>2</sup> (<sup>1,2</sup>United Technologies Research Center)

A New Prognostics Approach for Bearing Based on Entropy Decrease and Comparison with existing Methods — Seokgoo Kim<sup>1</sup>, Sungho Park<sup>2</sup>, Ju-Won Kim<sup>3</sup>, Junghwa Han<sup>4</sup>, Dawn An<sup>5</sup>, Nam Ho Kim<sup>6</sup>, Joo-Ho Choi<sup>7</sup> (<sup>1,2,7</sup>Korea Aerospace University, Korea; <sup>3,4</sup>Korea Railroad Corporation, Korea; <sup>5,6</sup>University of Florida)

**Paper Session 3B: Turbines**

Tuesday, 8:45 – 10:15, Room: Cripple Creek B

Session Chair: Ian Jennions — Cranfield University

Enhancing Turbine Performance Degradation Prediction with Atmospheric Factors — Xiaomo Jiang<sup>1</sup>, TsungPo Lin<sup>2</sup>, Eduardo Mendoza<sup>3</sup> (<sup>1,2,3</sup>General Electric Company)

Gas Turbine Engine Health Data Analysis for Parameter Reduction and Condition Assessment — Amar Kumar<sup>1</sup>, Alka Srivastava<sup>2</sup>, Nita Goel<sup>3</sup>, Marzia Zaman<sup>4</sup> (<sup>1,2,3,4</sup>Tecsis Corporation)

Method and System for Predicting Hydraulic Valve Degradation on a Gas Turbine — James D’Amato<sup>1</sup>, John Patanian<sup>2</sup> (<sup>1,2</sup>GE Power)

**Paper Session 4A: Data Challenge Winners**

Tuesday, 10:30 – 12:00, Room: Cripple Creek A

Session Chair: Nicholas Propeas — Seagate

<sup>†</sup>Invited paper published in IJPHM (www.ijphm.org)

**Paper Session 4B: Diagnostics II**

Tuesday, 10:30 – 12:00, Room: Cripple Creek B

Session Chair: Scott Clements — Lockheed Martin Aeronautics

A Computationally-Efficient Inverse Approach to Strain-Based Damage Diagnosis — James E. Warner<sup>1</sup>, Jacob D. Hochhalter<sup>2</sup>, William P. Leser<sup>3</sup>, Patrick E. Leser<sup>4</sup>, John A. Newman<sup>5</sup> (<sup>1,2,3,4,5</sup>NASA Langley Research Center)

Reducing Tachometer Jitter to Improve Gear Fault Detection — Eric Bechhoefer<sup>1</sup>, Dave He<sup>2</sup> (<sup>1</sup>GPMS Inc.; <sup>2</sup>University of Illinois at Chicago)

Distributed Adaptive Fault-Tolerant Formation Control of Second-Order Multi-Agent Systems with Actuator Faults — Mohsen Khalili<sup>1</sup>, Xiaodong Zhang<sup>2</sup>, Yongcan Cao<sup>3</sup> (<sup>1,2</sup>Wright State University; <sup>3</sup>University of Texas, San Antonio)

**Paper Session 5A: Industrial & Manufacturing Applications I**

Tuesday, 1:15 – 3:00, Room: Cripple Creek A

Session Chair: Douglas L. Van Bossuyt — Colorado School of Mines

Inertial Measurement Unit for On-Machine Diagnostics of Machine Tool Linear Axes — Gregory W. Vogl<sup>1</sup>, M. Alkan Donmez<sup>2</sup>, Andreas Archenti<sup>3</sup>, Brian A. Weis<sup>4</sup> (<sup>1,2,4</sup>National Institute of Standards and Technology; <sup>3</sup>KTH Royal Institute of Technology, Sweden)

Condition Based Monitoring for A Hydraulic Actuator — Stephen Adams<sup>1</sup>, Peter A. Beling<sup>2</sup>, Kevin Farinholt<sup>3</sup>, Nathan Brown<sup>4</sup>, Sherwood Polter<sup>5</sup>, Qing Dong<sup>6</sup> (<sup>1,2</sup>University of Virginia; <sup>3,4</sup>Luna Innovations Inc.; <sup>5,6</sup>Naval Surface Warfare Center)

<sup>†</sup>Present Status and Future Growth of Advanced Maintenance Technology and Strategy in US Manufacturing — Xiaoning Jin<sup>1</sup>, Brian A. Weiss<sup>2</sup>, David Siegel<sup>3</sup>, Jay Lee<sup>4</sup> (<sup>1</sup>Northeastern University; <sup>2</sup>National Institute of Standards and Technology; <sup>3,4</sup>University of Cincinnati)

**Paper Session 5B: Features II**

Tuesday, 1:15 – 3:00, Room: Cripple Creek B

Tuesday, October 4, 2016

Track C: Panel Sessions		Track D: Technology Demos		Location
Crestone A		Aspen AB		Time
Registration		Location: 3 <sup>rd</sup> Floor Foyer		7AM – 5PM
Continental Breakfast		Location: 3 <sup>rd</sup> Floor Foyer		7:45 – 8:00
Opening Remarks <b>Luminary Presentation: Dr. David Hilmers, former Astronaut, Baylor College of Medicine</b> “Dealing with Disaster in Space and on Earth”		Location: Crystal Ballroom		8:00 – 8:45
Panel Session 2: <b>Wind Energy</b> <i>Junda Zhu (NRG)</i>	Technology Demonstration: <b>Smartphone Based Multi-Modal Sensor Fusion for PHM [UTRC]</b>			8:45 – 10:15
Break		Location: 3 <sup>rd</sup> Floor Foyer		10:15 – 10:30
Panel Session 3: <b>Oil and Gas, Automation and PHM</b> <i>Rune Schlanbusch (Teknova AS)</i>	Technology Demonstration: <b>Machine Learning for Monitoring System Health [MathWorks]</b>			10:30 – 12:00
Conference Lunch		Location: Crystal Ballroom		12:00 – 1:15
<b>Keynote Speaker: Rhonda Whalhall, United Technologies Aerospace Systems</b> “The Role of PHM at Commercial Airlines”				
Panel Session 4: <b>Automotive PHM &amp; Advanced Analytics</b> <i>Steven W. Holland (General Motors)</i>	Technology Demonstration: <b>Rapid Oil Debris Identification via ChipCHECK [GasTOPS]</b>			1:15 – 3:00
Break		Location: 3 <sup>rd</sup> Floor Foyer		3:00 – 3:30
Panel Session 5: <b>PHM Education and Professional Development</b> <i>Jeff Bird (TECNos), Karl Reichard (Penn State)</i>	Technology Demonstration: <b>Smartphone Based Multi-Modal Sensor Fusion for PHM [UTRC]</b>			3:30 – 5:15
Poster Reception		Location: Crystal Ballroom		5:15 – 7:30

Session Chair: Jeff Bird — TECNos

Time Domain Reflectometry (TDR) Sensor Measurement in Contaminated Oils — Jonathan Geisheimer<sup>1</sup>, Shilpa Jagannath<sup>2</sup>, Farhana Zaman<sup>3</sup> (<sup>1,2,3</sup>Meggitt Sensing Systems)  
Evaluation of Features with Changing Effectiveness for Prognostics — Vepa Atamuradov<sup>1</sup>, Fatih Camci<sup>2</sup> (<sup>1</sup>Mevlana University, Turkey; <sup>2</sup>Antalya International University, Turkey)  
A Qualitative Fault Isolation Approach for Parametric and Discrete Faults Using Structural Model Decomposition — Matthew Daigle<sup>1</sup>, Anibal Bregon<sup>2</sup>, Indranil Roychoudhury<sup>3</sup> (<sup>1,3</sup>NASA Ames Research Center; <sup>2</sup>University of Valladolid, Spain; <sup>3</sup>SGT, Inc.)

**Paper Session 6A: Aviation II**

Tuesday, 3:30 – 5:15, Room: Cripple Creek A

Session Chair: Giovanni Jacazio — Polytechnic University of Turin

An Application of Data Driven Anomaly Identification to Spacecraft Telemetry Data — Gautam Biswas<sup>1</sup>, Hamed Khorasgani<sup>2</sup>, Gerald Stanje<sup>3</sup>, Abhishek Dubey<sup>4</sup>, Somnath Deb<sup>5</sup>, Sudipto Ghoshal<sup>6</sup> (<sup>1,2,3,4</sup>Vanderbilt University; <sup>5,6</sup>Qualtech Systems, Inc.)

System-Level Prognostics for The National Airspace — Matthew Daigle<sup>1</sup>, Shankar Sankaraman<sup>2</sup>, Indranil Roychoudhury<sup>3</sup> (<sup>1,2,3</sup>NASA Ames Research Center; <sup>2,3</sup>SGT, Inc.)

Prognostic Reasoner Based Adaptive Power Management System for A More Electric Aircraft — Robin Kuttikkadan Sebastian<sup>1</sup>, Suresh Perinpinayagam<sup>2</sup>, Alirza Alghassi<sup>3</sup> (<sup>1</sup>Hindustan Aeronautics Limited, India; <sup>2,3,4</sup>Cranfield University, UK)

**Paper Session 6B: Batteries I**

Tuesday, 3:30 – 5:15, Room: Cripple Creek B

Session Chair: Amir Kashani — University of Maryland

Remaining Useful Life Predictions in Lithium-Ion Battery Under Composite Condition — Yejin Kim<sup>1</sup>, Jongsoo Lee<sup>2</sup> (<sup>1,2</sup>Yonsei University, Republic Of Korea)

Particle-Filtering-Based State-Of-Health Estimation and Remaining Useful Life Prognosis for Lithium-Ion Batteries at Operation Temperature — Daniel Pola<sup>1</sup>, Felipe Guajardo<sup>2</sup>, Esteban Jofre<sup>3</sup>, Vanessa Quintero<sup>4</sup>, Aramis Perez<sup>5</sup>, David Acu~na<sup>6</sup>, Marcos Orchard<sup>7</sup> (<sup>1,2,3,4,5,6,7</sup>Universidad de Chile, Chile)

Used Lubricating Oil Filter Debris Analysis (FDA) for Problem Diagnostic of Oil Lubricated Machinery — Surapol Raadnu<sup>1</sup> (<sup>1</sup>King Mongkut’s University of Technology North Bangkok, Thailand)

## Technology Demonstrations

Tuesday, October 4, 2016

Aspen AB

UTRC

8:45 – 10:15 and 3:30 – 5:15

Smartphone Based Multi-Modal Sensor Fusion for PHM

MathWorks

10:30 – 12:00

Machine Learning for Monitoring System Health

GasTOPS

1:15 – 3:00

Rapid Oil Debris Identification via ChipCHECK

Wednesday, October 5, 2016

Aspen AB

Metis/UTAS

8:45 – 9:15, 9:45 – 10:15, 3:30 – 4:00 and 4:30 – 5:15

PHM for Static Components

MathWorks

10:30 – 12:00

Machine Learning for Monitoring System Health

GasTOPS

1:15 – 3:00

Rapid Oil Debris Identification via ChipCHECK

Location Time	Track A: Technical Paper Sessions	Track B: Technical Paper Sessions	
	Cripple Creek A	Cripple Creek B	
7AM – 5PM	Registration		Location: 3 <sup>rd</sup> Floor Foyer
7:45 – 8:00	Continental Breakfast		Location: 3 <sup>rd</sup> Floor Foyer
8:00 – 8:45	Opening Remarks <b>Luminary Presentation: Dr. Daniel Mack, <i>Kansas City Royals</i></b> “Diagnostics with a Noisy Sensor: From Aircraft to Player Performance”		Location: Crystal Ballroom
8:45 – 10:15	Paper Session 7A: <b>Deep Learning I</b>	Paper Session 7B: <b>Systems II</b>	
10:15 – 10:30	Break		Location: 3 <sup>rd</sup> Floor Foyer
10:30 – 12:00	Paper Session 8A: <b>Data Driven Methods</b>	Paper Session 8B: <b>Prognostics II</b>	
12:00 – 1:15	Lunch on your own		
1:15 – 3:00	Paper Session 9A: <b>Missing Data</b>	Panel Session 8: <b>Railway PHM</b> <i>David Siegel (Predictronics)</i>	
3:00 – 3:30	Break		Location: 3 <sup>rd</sup> Floor Foyer
3:30 – 5:15	Paper Session 10A: <b>Deep Learning II</b>	Paper Session 10B: <b>Industrial &amp; Manufacturing Applications II</b>	
5:15 – 5:30	Free Time		
5:30 – 6:00	Buses to Banquet		
6:00 – 9:30	PHM Conference Banquet Sports Authority at Mile High Stadium		For guest tickets, please see Registration Desk
9:30 – 10:00	Busses Return to Hotel		
<i>For Co-located DX-2016 Session Schedule, see Page 11</i>			

**Paper Session 7A: Deep Learning I**

Wednesday, 8:45 – 10:15, Room: Cripple Creek A  
 Session Chair: Steven Adams — University of Virginia

**Deep Learning Based Diagnostics of Orbit Patterns in Rotating Machinery** — Haedong Jeong<sup>1</sup>, Sunhee Woo<sup>2</sup>, Suhyun Kim<sup>3</sup>, Seungtae Park<sup>4</sup>, Heechang Kim<sup>5</sup>, Seungchul Lee<sup>6</sup> (<sup>1,2,3,4,5,6</sup>Ulsan National Institute of Science and Technology, Korea)

**Using Deep Learning Based Approaches for Bearing Fault Diagnosis with AE Sensors** — Miao He<sup>1</sup>, David He<sup>2</sup>, Eric Bechhoefer<sup>3</sup> (<sup>1,2</sup>University of Illinois at Chicago; <sup>3</sup>Green Power Monitoring Systems)

<sup>†</sup>**Combining Deep Learning and Survival Analysis for Asset Health Management** — Linxia Liao<sup>1</sup>, Hyung-il Ahn<sup>2</sup> (<sup>1</sup>GE Digital; <sup>2</sup>Noodle Analytics, Inc.)

**Paper Session 7B: Systems II**

Wednesday, 8:45 – 10:15, Room: Cripple Creek B  
 Session Chair: Carl Byington — Impact Technologies/Sikorsky, A Lockheed Martin Company

**Case Study in Improving the Health of a Remote Monitoring & Diagnostics Center** — Sanjeev Heda<sup>1</sup> (<sup>1</sup>GE Power)

**Critical Components Selection for A Prognostics and Health Management System Design: An Application to an Overhead Contact Line System** — M. Brahim<sup>1</sup>, K. Medjaher<sup>2</sup>, M. Leouatni<sup>3</sup>, N. Zerhouni<sup>4</sup> (<sup>1,4</sup>FEMTO-ST Institute, France; <sup>1,3</sup>ALSTOM, France; <sup>2</sup>INP-ENIT, France)

<sup>†</sup>Invited paper published in IJPHM (www.ijphm.org)

**Engine Health Management in Safran Aircraft Engines** — Guillaume Bastard<sup>1</sup>, Jérôme Lacaille<sup>2</sup>, Josselin Coupard<sup>3</sup>, Yacine Stouky<sup>4</sup> (<sup>1,2,3,4</sup>Safran Aircraft Engines, France)

**Paper Session 8A: Data Driven Methods**

Wednesday, 10:30 – 12:00, Room: Cripple Creek A  
 Session Chair: Jon Bednar — Boeing

**A Data-Driven Health Management Application for Failure Detection and Diagnosis in Electrical Submersible Pumps** — Supriya Gupta<sup>1</sup>, Michael Nikolaou<sup>2</sup>, Luigi Saputelli<sup>3</sup> (<sup>1,2</sup>University of Houston; <sup>3</sup>Frontender Corporation)

**Reciprocating Compressor Valve Condition Monitoring Using Image-Based Pattern Recognition** — John N. Trout<sup>1</sup>, Jason R. Kolodziej<sup>2</sup> (<sup>1,2</sup>Rochester Institute of Technology; <sup>3</sup>Instituto Tecnológico de Aeronautica, Brazil)

**Comparison of Model-Based Vs. Data-Driven Methods for Fault Detection and Isolation in Engine Idle Speed Control System** — Ruochen Yang<sup>1</sup>, Giorgio Rizzoni<sup>2</sup> (<sup>1,2</sup>Center for Automotive Research; <sup>1,2</sup>Ohio State University)

**Paper Session 8B: Prognostics II**

Wednesday, 10:30 – 12:00, Room: Cripple Creek B  
 Session Chair: Ash Thacker — Global Technology Connection

**Deriving Prognostic Continuous Time Bayesian Networks from Fault Trees** — Logan Perreault<sup>1</sup>, Monica Thornton<sup>2</sup>, John W. Sheppard<sup>3</sup> (<sup>1,2,3</sup>Montana State University)

**Probabilistic Prognosis of Non-Planar Fatigue Crack Growth** — Patrick E. Leser<sup>1</sup>, John A. Newman<sup>2</sup>, James E. Warner<sup>3</sup>,

Wednesday, October 5, 2016

Track C: Panel Sessions		Track D: Technology Demos		Location
Crestone A		Aspen AB		Time
Registration		Location: 3 <sup>rd</sup> Floor Foyer		7AM – 5PM
Continental Breakfast		Location: 3 <sup>rd</sup> Floor Foyer		7:45 – 8:00
Opening Remarks		Location: Crystal Ballroom		8:00 – 8:45
<b>Luminary Presentation: Dr. Daniel Mack, Kansas City Royals</b> “Diagnostics with a Noisy Sensor: From Aircraft to Player Performance”				
Panel Session 6: <b>PHM Standards Experience for Manufacturing</b> <i>Jeff Bird (Rogers), Ravi Rajamani (drR2 Consulting)</i>	Technology Demonstration: <b>PHM for Static Components</b> <b>[Metis/UTAS]</b>		8:45 – 10:15	
Break		Location: 3 <sup>rd</sup> Floor Foyer		10:15 – 10:30
Panel Session 7: <b>Smart Manufacturing PHM</b> <i>Brian A. Weiss (NIST)</i>	Technology Demonstration: <b>Machine Learning for Monitoring</b> <b>System Health [MathWorks]</b>		10:30 – 12:00	
Lunch on your own				12:00 – 1:15
Panel Session 9: <b>Department of Defense (DoD) Condition Based Maintenance Plus (CBM+) Service Panel Review</b> <i>Kevin Bostick (U.S. Army)</i>	Technology Demonstration: <b>Rapid Oil Debris Identification</b> <b>via ChipCHECK [GasTOPS]</b>		1:15 – 3:00	
Break		Location: 3 <sup>rd</sup> Floor Foyer		3:00 – 3:30
Panel Session 10: <b>Select Military Maintenance Projects Funded through the Commercial Technologies for Maintenance Activities (CTMA) Program</b> <i>Debbie Lili (NCMS)</i>	Technology Demonstration: <b>PHM for Static Components</b> <b>[Metis/UTAS]</b>		3:30 – 5:15	
Free Time				5:15 – 5:30
Buses to Banquet				5:30 – 6:00
PHM Conference Banquet Sports Authority at Mile High Stadium		For guest tickets, please see Registration Desk		6:00 – 9:30
Busses Return to Hotel				9:30 – 10:00
<i>For Co-located DX-2016 Session Schedule, see Page 11</i>				

William P. Leser<sup>4</sup>, Jacob D. Hochhalter<sup>5</sup>, Fuh-Gwo Yuan<sup>6</sup>  
 (<sup>1,2,3,4,5</sup>NASA Langley Research Center; <sup>6</sup>North Carolina State University)

A Modelling Ecosystem for Prognostics — L. Astfalck<sup>1</sup>, M.R. Hodkiewicz<sup>2</sup>, A. Keating<sup>3</sup>, E. Cripps<sup>4</sup>, M. Pecht<sup>5</sup> (<sup>1,2,3,4</sup>University of Western Australia, Australia; <sup>5</sup>University of Maryland)

**Paper Session 9A: Missing Data**

Wednesday, 1:15 – 3:00, Room: Cripple Creek A

Session Chair: Peter Beling — University of Virginia

Application of Multiple-Imputation-Particle-Filter For Parameter Estimation of Visual Binary Stars with Incomplete Observations — Rubén M. Clavería<sup>1</sup>, David Acuña<sup>2</sup>, René A. Mendez<sup>3</sup>, Jorge F. Silva<sup>4</sup>, Marcos E. Orchard<sup>5</sup> (<sup>1,2,3,4,5</sup>Universidad de Chile, Chile)

Failure Prognostics with Missing Data Using Extended Kalman Filter — Wlamiir Olivares Loesch Vianna<sup>1</sup>, Takashi Yoneyama<sup>2</sup> (<sup>1</sup>EMBRAER S.A., Brazil; <sup>2</sup>Instituto Tecnológico de Aeronautica, Brazil)

†On the Practical Performance of Minimal Hitting Set Algorithms from a Diagnostic Perspective — Ingo Pill<sup>1</sup>, Thomas Quaritsch<sup>2</sup>, Franz Wotawa<sup>3</sup> (<sup>1,2,3</sup>Graz University of Technology, Austria; <sup>2</sup>HTL Pinkafeld)

**Paper Session 10A: Deep Learning II**

Wednesday, 3:30 – 5:15, Room: Cripple Creek A

†Invited paper published in IJPHM (www.ijphm.org)

Session Chair: Scott Clements — Lockheed Martin Aeronautics  
 Deep Health Indicator Extraction: A Method Based On Auto-Encoders and Extreme Learning Machines — Yang Hu<sup>1</sup>, Thomas Palmé<sup>2</sup>, Olga Fink<sup>3</sup> (<sup>1,3</sup>Zurich University of Applied Sciences, Switzerland; <sup>2</sup>General Electric, Switzerland)  
 Using Deep Learning Based Approaches for Bearing Remaining Useful Life Predication — Jason Deutsch<sup>1</sup>, David He<sup>2</sup> (<sup>1,2</sup>University of Illinois at Chicago)  
 Deep Learning for Structural Health Monitoring: A Damage Characterization Application — Soumalya Sarkar<sup>1</sup>, Kishore K. Reddy<sup>2</sup>, Michael Giering<sup>3</sup>, Mark R. Gurvich<sup>4</sup> (<sup>1,2,3,4</sup>United Technologies Research Center)

**Paper Session 10B: Industrial & Manufacturing Applications II**

Wednesday, 3:30 – 5:15, Room: Cripple Creek B

Session Chair: Brian A. Weiss — National Institute of Standards  
 Case Study of a Faulted Planet Bearing — Eric Bechhoefer<sup>1</sup>, Dave He<sup>2</sup> (<sup>1</sup>GPMS Inc.; <sup>2</sup>University of Illinois at Chicago)  
 Towards Detection of Water Management Faults for PEM Fuel Cells Under Variable Load — Pavle Bošković<sup>1</sup>, Andrej Debenjak<sup>2</sup>, Đani Juric<sup>3</sup>, Biljana Mileva Boshkoska<sup>4</sup> (<sup>1,2,3</sup>Jožef Stefan Institute, Slovenia; <sup>4</sup>Faculty of Information Studies in Novo mesto, Slovenia)  
 Hidden Markov Model Based Detection and Classification of Foreign Objects in Heat-Exchanger Tubes — Portia Banerjee<sup>1</sup>, Lalita Udpa<sup>2</sup>, Satish Udpa<sup>3</sup> (<sup>1,2,3</sup>Michigan State University)

Location Time	Track A: Technical Paper Sessions	Track B: Technical Paper Sessions	
	Cripple Creek A	Cripple Creek B	
7AM – 12PM	Registration		Location: 3 <sup>rd</sup> Floor Foyer
7:45 – 8:00	Continental Breakfast		Location: 3 <sup>rd</sup> Floor Foyer
8:00 – 8:45	Opening Remarks <b>Joint PHM/DX Keynote Presentation: Dr. Rui Abreu, PARC</b> “Testing and Debugging Software-Intensive Systems”		Location: Crystal Ballroom
8:45 – 10:15	Paper Session 11A: <b>Structural Health Management</b>	Paper Session 11B: <b>Batteries II</b>	
10:15 – 10:30	Break		Location: 3 <sup>rd</sup> Floor Foyer
10:30 – 12:00	Paper Session 12A: <b>PHM for Electrical Systems</b>	Paper Session 12B: <b>Deep Learning III</b>	
12:00 – 1:15	Lunch on your own		
1:15 – 3:00	<i>Reserved for PHM Conference</i>		
3:00 – 3:30	Closing Remarks		Location: Crestone A
<i>Continue to Enjoy DX-2016 and Denver. See You in 2017 in St. Petersburg, FL!</i>			

**Paper Session 11A: Structural Health Management**

Thursday, 8:45 – 10:15, Room: Cripple Creek A

Session Chair: Abbas Chokor — Arizona State University

Detection of Fatigue Cracks in Shafts Via Analysis of Vibrations and Orbital Paths — R. Peretz<sup>1</sup>, L. Rogel<sup>2</sup>, J. Bortman<sup>3</sup>, R. Klein<sup>4</sup> (<sup>1,2,3</sup>Ben-Gurion University of the Negev, Israel; <sup>4</sup>R.K. Diagnostics, Israel)

†Big Data Analytics in Online Structural Health Monitoring — Guowei Cai<sup>1</sup>, Sankaran Mahadevan<sup>2</sup> (<sup>1,2</sup>Vanderbilt University)

Quadrotor Actuator Fault Diagnosis with Real-Time Experimental Results — Remus Avram<sup>1</sup>, Xiaodong Zhang<sup>2</sup>, Mohsen Khallil<sup>3</sup> (<sup>1,2,3</sup>Wright State University)

**Paper Session 11B: Batteries II**

Thursday, 8:45 – 10:15, Room: Cripple Creek B

Session Chair: Peter Beling — University of Virginia

Parameters Optimization of Lebesgue Sampling-Based Fault Diagnosis and Prognosis with Application to Li-Ion Batteries — Wuzhao Yan<sup>1</sup>, Bin Zhang<sup>2</sup>, Marcos Orchard<sup>3</sup> (<sup>1,2</sup>University of South Carolina; <sup>3</sup>Universidad de Chile, Chile)

A Fusion Method Based On Unscented Particle Filter and a Naive Bayes Model for Lithium-Ion Battery Remaining Useful Life Prediction — Jiayu Chen<sup>1</sup>, Dong Zhou<sup>2</sup>, Chuan Lu<sup>3</sup> (<sup>1,2,3</sup>Beihang University, China)

Data-Driven Prognostics of Lithium-Ion Rechargeable Battery Using Bilinear Regression — Charlie Hubbard<sup>1</sup>, John Bavlsik<sup>2</sup>, Chinmay Hegde<sup>3</sup>, Chao Hu<sup>4</sup> (<sup>1,2,3,4</sup>Iowa State University)

**Paper Session 12A: PHM for Electrical Systems**

Thursday, 10:30 – 12:00, Room: Cripple Creek A

Session Chair: José Celaya — Schlumberger

A Review of Photovoltaic Systems Prognostics and Health Management: Challenges and Opportunities — Abbas Chokor<sup>1</sup>, Mounir El Asmar<sup>2</sup>, Sumanth V. Lokanath<sup>3</sup> (<sup>1,2</sup>Arizona State University; <sup>3</sup>First Solar Inc.)

Failure Precursor Identification and Degradation Modeling for Insulated Gate Bipolar Transistors Subjected to Electrical Stress — Junmin Lee<sup>1</sup>, Hyunseok Oh<sup>2</sup>, Chan Hee Park<sup>3</sup>, Byeng D. Youn<sup>4</sup>, Deog Hyeon Kim<sup>5</sup>, Byung Hwa Kim<sup>6</sup>, Yong Un Cho<sup>7</sup> (<sup>1,2,3,4</sup>Seoul National University, Republic of Korea; <sup>5,6,7</sup>Hyundai Motor Group, Republic of Korea; <sup>1,5,6</sup>General Motors Global R&D)

Impedance-Based Health Monitoring of Electromagnetic Coil Insulation Subjected to Corrosive Deterioration — N. Jordan Jameson<sup>1</sup>, Michael H. Azarian<sup>2</sup>, Michael Pecht<sup>3</sup> (<sup>1,2,3</sup>CALCE, University of Maryland)

**Paper Session 12B: Deep Learning III**

Thursday, 10:30 – 12:00, Room: Cripple Creek B

Session Chair: David Siegel — Predictrionics

†Wearable EEG-based Activity Recognition in PHM-related Service Environment via Deep Learning — Soumalya Sarkar<sup>1</sup>, Kishore Reddy<sup>2</sup>, Alex Dorgan<sup>3</sup>, Cali Fidopiastis<sup>4</sup>, Michael Giering<sup>5</sup> (<sup>1,2,3,4,5</sup>United Technologies Research Center)

Smart Diagnosis of Journal Bearing Rotor Systems: Unsupervised Feature Extraction Scheme by Deep Learning — Hyunseok Oh<sup>1</sup>, Byung Chul Jeon<sup>2</sup>, Joon Ha Jung<sup>3</sup>, Byeng D. Youn<sup>4</sup> (<sup>1,2,3,4</sup>Seoul National University, Republic of Korea)

†Prognostics of Combustion Instabilities from Hi-speed Flame Video using a Deep Convolutional Selective Autoencoder — Adedotun Akintayo<sup>1</sup>, Kin Gwn Lore<sup>2</sup>, Soumalya Sarkar<sup>3</sup>, Soumik Sarkar<sup>4</sup> (<sup>1,2,4</sup>Iowa State University; <sup>3</sup>United Technologies Research Center)



<sup>†</sup>Invited paper published in IJPHM (www.ijphm.org)

Thursday, October 6, 2016

Track C: Panel Sessions		Track D: Technology Demos		Location
Crestone A		Aspen AB		Time
Registration		Location: 3 <sup>rd</sup> Floor Foyer		7AM – 12PM
Continental Breakfast		Location: 3 <sup>rd</sup> Floor Foyer		7:45 – 8:00
Opening Remarks		Location: Crystal Ballroom		8:00 – 8:45
<b>Joint PHM/DX Keynote Presentation: Dr. Rui Abreu, PARC</b> “Testing and Debugging Software-Intensive Systems”				
Panel Session 11: <b>Big Data Analytics</b> <i>Jonathan Bednar (Boeing)</i>		Reserved for PHM Conference		8:45 – 10:15
Break		Location: 3 <sup>rd</sup> Floor Foyer		10:15 – 10:30
<b>PHM2017 Planning Session</b> <i>Volunteers Welcome!</i>		Reserved for PHM Conference		10:30 – 12:00
Lunch on your own				12:00 – 1:15
Panel Session 12: <b>Fielded Systems</b> <i>Andy Hess (The Hess PHM Group)</i>		Reserved for PHM Conference		1:15 – 3:00
Closing Remarks		Location: Crestone A		3:00 – 3:30
<i>Continue to Enjoy DX-2016 and Denver. See You in 2017 in St. Petersburg, FL!</i>				

## 27<sup>th</sup> International Workshop on Principles of Diagnosis: DX-2016 (Held concurrently with PHM2016)

### Session I

Wednesday, 10:30 – 12:00, Room: Crestone B

Using Partial Diagnoses for Sequential Model-Based Fault Localization — Kostyantyn Shchekotykhin, Thomas Schmitz, Dietmar Jannach

Diagnosability of Discrete-Event Systems with Uncertain Observations — Xingyu Su, Marina Zanella, Alban Grastien

Applying Simulated Annealing to Problems in Model-based Diagnosis — Alexander Diedrich, Alexander Feldman, Alejandro Perdomo-Ortiz, Rui Abreu, Johan de Kleer, Oliver Niggemann

### Session II

Wednesday, 1:15 – 3:00, Room: Crestone B

Diagnosing PARC's Refrigerator Benchmark with Data-Driven Methods — Alexander Feldman, Rui Abreu, Bhaskar Saha, Anurag Ganguli, Johan de Kleer

An Unsupervised Approach to Anomaly Detection from Aircraft Flight Data — Daniel LC Mack, Gautam Biswas, Dinkar Mylaraswamy, Raj Bharadwaj

A Novel Anomaly Detection Algorithm for Hybrid Production Systems based on Deep Learning and Timed Automata — Nemanja Hranisavljevic, Oliver Niggemann, Alexander Maier

### Session III

Wednesday, 3:30 – 5:15, Room: Crestone B

Minimal Hitting Set Computation via Hypothesis Exploration — Marina Zanella, Ingo Pill

Model-Based Diagnosis using Variable-Fidelity Modeling — Gregory Provan

Exploiting Structural Metrics in FMEA-Based Abductive Diagnosis — Roxane Koitz, Franz Wotawa

### Session IV

Thursday, 10:30 – 12:00, Room: Crestone B

A  $\pi$ -Calculus Formalization of Contract Violation Diagnosis — Gianluca Torta, Roberto Micalizio

Solving Sequential Diagnosis by Compilation to Boolean Satisfiability — Ester Lazebnik, Roni Stern, Meir Kalech

Solving Diagnosability of Hybrid Systems via Abstraction and Discrete-Event Techniques — Alban Grastien, Louise Travé-Massuyès, Vicenç Puig

### Session V

Friday, 8:30 – 10:00, Room: Crestone B

Diagnosability Planning for Controllable Discrete Event Systems — Hassan Ibrahim, Philippe Dague, Alban Grastien, Lina Ye, Laurent Simon

A General Characterization of Model-Based Diagnosis — Gregory Provan

### Session VI

Friday, 10:30 – 12:00, Room: Crestone B

Fault-Driven Minimal Structurally Overdetermined Set in a Distributed Context — Gustavo Pérez, Elodie Chanthery, Louise Travé-Massuyès, Javier Sotomayor

Diagnosis of Intermittent Faults with Conditional Preferences — Cédric Pralet, Xavier Pucel, Stéphanie Roussel

## Job Fair

The PHM Society is holding a Job Fair within the PHM16 conference in Denver, CO. The PHM Job Fair is an exposition for PHM employers to meet with prospective job seekers. The Job Fair is FREE and OPEN to all registered PHM16 conference participants. Candidates of all ages, all levels of experience, and all industries are encouraged to attend. For further details or questions, please contact us on (need email address here). Check at Registration Desk for locations/times.

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# A Short Course on PHM Fundamentals and Cases Studies

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Sunday, October 1 – 2, Room: Crystal Ballroom AB  
*Separate Registration Required*

The PHM Society offers this updated two-day intensive short course titled PHM Fundamentals and Case Studies—from Monitoring/Sensing to Fault Diagnosis/Failure Prognosis and Case Studies, on PHM tools, methods, applications and case studies on October 1 and 2 in Denver USA right before the PHM16 conference. This follows from the first offering at the PHM14 conference in Fort Worth, TX with 48 attendees and ratings of 4/5. It was also run in 2015 in San Diego and 2016 in Bilbao, Spain.

This fourth offering of the course is presented by recognized 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.

Comprehensive introduction and two workshop sessions for detailed analysis

Needs, Requirements and Metrics, Diagnostics, Prognostics and Data Analytics

Condition Based Maintenance, Data Requirements, Cost Benefit Analysis and Reliability

Seven real world case studies: aerospace bearings, batteries, data fusion, land vehicles, UAVs

Presenters from drR<sup>2</sup>, GE, Georgia Tech, NASA, Penn State, Schlumberger and TECnos

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## Doctoral Symposium

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Sunday, 1:00 – 9:00, Room: Aspen AB

*Session Chairs: Jamie Coble – Univ. of Tennessee, Knoxville*

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 two days of the conference. The panelists for the DS are:

Ravi Rajamani, *drR<sup>2</sup> Consulting*

Jose Celaya, *Schlumberger*

Nicholas Propes, *Seagate*

Gautam Biswas, *Vanderbilt University*

### Doctoral Symposium Session 1

Sunday, 1:15 – 3:00, Room: Aspen AB

*Circuit Breaker Health and Reliability Monitoring: The Key to Realizing a Smarter Electricity Grid* – Payman Dehghanian, *Texas A&M University*

*Algorithms for Hybrid Diagnostics of Nonlinear Systems* – Turki Haj Mohamad, *Villanova University*

*Fault-Tolerant Supervisory Control Mechanism for Chiller Plants* – Khushboo Mittal, *University of Connecticut*

### Doctoral Symposium Session 2

Sunday, 3:30 – 5:30, Room: Aspen AB

*Bayesian Cramér-Rao Bounds for Time-of-Failure Probability*

*Mass Function Estimation* – David Acuña, *University of Chile*  
*Development of Deep Learning Based Approaches for Rotating Machinery Fault Diagnosis with Big Data* – Miao He, *University of Illinois at Chicago*

*Model-Based Failure Prognosis Approach for Complex Systems to Support Asset Management* – Olivier Blancke, *École de Technologie Supérieure*

*Toward Battery Health Management for Small-size Battery-powered Rotary-wing Aircraft* – Gina Sierra, *University of Chile*

### Doctoral Symposium Session 3

Sunday, 6:30 – 8:30, Room: Aspen AB

*Deep Learning Based Diagnosis of Journal Bearing Rotor Systems* – Joon Ha Jung, *Seoul National University*

*Probabilistic Pipe Strength and Toughness Estimation through Information Fusion with Bayesian Updating* – Sonam Dahire, *Arizona State University*

*Meta Learning for Fault Tolerant PHM Systems Considering Correlated Failures* – Saikath Bhattacharya, *University of Massachusetts Dartmouth*

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## Tutorials

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As educational events, tutorials provide a comprehensive introduction to the state-of-the-art. 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. The tutorials will be Monday morning and are free of charge to all registrants. 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 1A: Diagnostics

Monday, 8:00 – 9:45, Room: Cripple Creek A

Matthew Daigle

*NASA Ames Research Center*

Indranil Roychoudhury

*SGT Inc., NASA Ames Research Center*

*Abstract:* The area of diagnostics is focused on the detection, isolation, and identification of system faults. Diagnostics is critical in guaranteeing correct, efficient, and safe operation of complex systems. In model-based diagnostics, faults are diagnosed by reasoning over a model of the system that captures both nominal and faulty behavior. While model-based diagnosis of static systems is well-established, diagnosis of dynamic systems presents a number of additional challenges, and many different approaches have been developed to handle them using different kinds of models and reasoning algorithms. This tutorial will present the general approach of model-based diagnostics, survey different fault diagnosis approaches available in literature, and present a framework for model-based diagnosis of dynamic systems. Advanced concepts of structural model decomposition and distributed diagnosis will also be presented. Case studies will be used to explain the concepts and demonstrate their application to real-world systems.

*Presenter Bios:* Matthew Daigle received the B.S. degree in Computer Science and Computer and Systems Engineering from Rensselaer Polytechnic Institute, Troy, NY, in 2004, and the M.S. and Ph.D. degrees in Computer Science from Vanderbilt University, Nashville, TN, in 2006 and 2008, respectively. From September 2004 to May 2008, he was a Graduate Research Assistant with the Institute for Software Integrated Systems and Department of Electrical Engineering and Computer Science, Vanderbilt University, Nashville, TN. During the summers of 2006 and 2007, he was

an intern with Mission Critical Technologies, Inc., at NASA Ames Research Center. From June 2008 to December 2011, he was an Associate Scientist with the University of California, Santa Cruz, at NASA Ames Research Center. Since January 2012, he has been with NASA Ames Research Center as a Research Computer Scientist. His current research interests include physics-based modeling, model-based diagnosis and prognosis, simulation, and hybrid systems. Dr. Daigle is a member of the Prognostics and Health Management Society and the IEEE.

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. Since August 2009, he has been with SGT, Inc., at NASA Ames Research Center as a Computer Scientist. 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 Senior Member of the IEEE and a member of the Prognostics and Health Management Society and the AIAA.

### **Tutorial Session 1B: An Introduction to Data-Driven Prognostics of Engineered Systems**

Monday, 8:00 – 9:45, Room: Cripple Creek B

Jamie Baalis Coble

University of Tennessee, Knoxville

*Abstract:* Approaches to prognosis of components and systems are typically divided into model-based and data-driven algorithms. Model-based algorithms rely on first principles based physics of failure models of the evolution of degradation. Data-driven methods use historic run-to-failure and accelerated degradation test data to discover the underlying relationships between measured data and equipment lifetime. Algorithms for data-driven prognostics can be categorized into three types according to the type of information used for prognosis, generally in order of greater specificity and accuracy. Type I (reliability-based) prognostics uses traditional reliability analysis to estimate the lifetime of an average component operating under average conditions. Type II (stressor-based) prognostics incorporate information about how a component or system will be operated (e.g., load, temperature, speed, pressure, demand) to evaluate the lifetime of an average component operating in some specific environment. Type III (degradation-based) prognostics track the condition of a specific component under its specific operation. This condition (or some measure indicative thereof) can be trended to failure.

This tutorial will introduce the general concept of prognostics and place it into context in a full health management system. Empirical prognostic algorithms in each of the three types will be presented.

*Presenter Bio:* Dr. Jamie Baalis Coble is an Assistant Professor in the Nuclear Engineering department at the University of Tennessee, Knoxville. Dr. Coble's expertise is primarily in statistical data analysis, empirical modeling, and advanced pattern recognition for equipment condition assessment, process and system monitoring, anomaly detection and diagnosis, and failure prognosis. Dr. Coble is currently pursuing research in prognostics and health management for active components and systems. Her research interests expand on past work in monitoring and prognostics to incorporate remaining useful life estimates into risk assessment, operations and maintenance planning, and optimal control algorithms. Prior to joining the faculty at UTK, she worked in the Applied Physics group at Pacific Northwest National Laboratory. Her work there focused primarily on data analysis and feature extraction for detecting anomalies and degradation in large passive components (e.g.,

concrete structures, pipes, welds), advanced active components (e.g., pumps, motors, valves), and other nuclear systems.

### **Tutorial Session 2A: Security Prognostics**

Monday, 10:15 – 12:00, Room: Cripple Creek A

Scott C. Evans

General Electric Global Research

*Abstract:* In this Tutorial we cast a vision for Security Prognostics (SP) for critical systems, promoting the view that security related protections would be well served to integrate fully with Monitoring and Diagnostics (M&D) systems that assess the health of complex assets and systems. To detect complex Cyber threats we propose combining system parameters already in use by M&D systems for Prognostics and Health Monitoring (PHM) with security parameters. Combining system parameters used by M&D to detect non-malicious faults with the system parameters used by security schemes to detect complex Cyber threats will improve: (a) accuracy of PHM (b) security of M&D, and (c) availability and safety of critical systems. We also introduce the notion of Remaining Secure Life (RSL), assessed based on the propagation of "security damage," to create the prospect for Security Prognostics. RSL will assist in the selection of appropriate response(s), based on breach or compromise to security component's and potential impact on system operation. An example of M&D data is provided which is normally associated with non-malicious faults providing input to detect Malware execution through time series monitoring.

*Presenter Bio:* Dr. Scott C. Evans is Senior Research Engineer in the Machine Learning Lab at General Electric Global Research in Niskayuna, NY. He has 39 patents and over 45 publications in the areas of algorithms, wind analytics, sequence analysis, cyber-security, and wireless network routing / Quality of Service (QoS). Scott holds a PHD in Electrical Engineering from Rensselaer Polytechnic Institute, an MS in Electrical Engineering from the University of Connecticut and a BS in Electrical Engineering from Virginia Tech. Scott is currently a key contributor and machine learning task leader on a \$5.6 million IARPA program applying machine learning and causal inference to detect insider threat. Before joining General Electric Research, Scott served as a nuclear-trained Submarine Officer in the United States Navy.

### **Tutorial Session 2B: Big Data Analytics**

Monday, 10:15 – 12:00, Room: Cripple Creek B

John Patanian

General Electric Power

*Abstract:* Big Data is a widely used, perhaps overused term when discussing modern analytics applications. While there is a lot of hype, there are many examples of not previously feasible capabilities enabled by big data technologies, such as large scale exploratory analysis, feature engineering and predictive modeling.

In open source software, Big Data is synonymous with the Apache Hadoop tech stack. The presentation will review key analytics related components of Hadoop including HDFS, Kafka, Hive, Spark, Sqoop, Oozie, and Yarn and their function in batch, interactive, and streaming use cases. Special attention will be given to how analytics have greatly expanded in the transition to Apache Spark and the inclusion of Python and R as first class components.

The tutorial will feature an applied example where Big Data tools were used in developing an anomaly detection algorithm.

*Presenter Bio:* John Patanian is Principal Engineer, analytics for GE power and has over 20 years experience in software development, machinery diagnostics, product management, controls optimization, and thermodynamic performance. He holds a masters degree in Computer Science from the University of Washington and a Bachelor's degree in Mechanical Engineering from Rensse-

laer Polytechnic Institute. He holds two U.S. Patents and served in the ASME PTC46 committee on performance testing of Combined Cycle power plants.

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## Panel Sessions

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### Panel Session 1: PHM For Human Assets I & II

Monday, 1:45 – 3:30 & 3:45 – 5:30, Room: Crestone A

Session Chair: *Wolfgang Fink – University of Arizona*

Predictive Health Management (PHM) originated in the Aerospace Industry, basically trying to predict when what part would fail for what reason(s) in order to make (preventive) maintenance more efficient and cost-effective. This panel discusses 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 performance on Earth and in Space. Moreover, this panel builds on the discussions of the experience and processes encountered/created by the panelists and highlights some specific challenges, needs, and wants with respect to the development and implementation of standards and guidelines pertaining to PHM in the area of human assets. This diverse group of panelists present their standards and guidelines perspectives on PHM for human assets. Conversations will include PHM's current and envisioned applications within general health-care, theatre, and space environments along with how the needs, data stream, and supporting PHM tools, can be better designed, developed, implemented, verified, and validated to impact smart healthcare.

*Panelists:*

*David Hilmers, Baylor College of Medicine*  
*Dorit Donoviel, NSBRI*  
*Col. ret. Ron Poropatic, University of Pittsburgh*  
*Mark Derriso, Wright-Patterson AFB*  
*Dragan Djurdjanovic, University of Texas-Austin*

### Panel Session 2: Wind Energy

Tuesday, 8:45 – 10:15, Room: Crestone A

Session Chair: *Junda Zhu – NRG*

The nature of the planetary section design of wind turbine gear-boxes calls for the most advanced prognostics and health management solutions in hardware, software, logistics and algorithm perspective. These technology advancements require field and lab based testing along with the valuable experience from wind farm operators and maintenance practices. Moreover, due to the stochastic nature of wind speed and direction, the operating condition of wind turbine drivetrain is continuously fluctuating. Combined with the dynamic adjustment from the control system, it is a global challenge to offer robust diagnostic solutions that can provide stable and accurate readings regardless of the operating condition variation. On top of that, prognostics capability is also crucial to optimize the wind farm maintenance strategy and maximize turbine availability and production rate. Therefore, as more and more owners and operators adopting the predictive maintenance strategy, PHM technology will be an irreplaceable tool on the fleet, system and component level maintenance planning.

*Panelists:*

*Shawn Sheng, NREL*  
*Zhiwei Zhang, Romax*  
*Alex Byrne, DNV GL*  
*Junda Zhu, NRG*

### Panel Session 3: Oil and Gas, Exploration and Production

Tuesday, 10:30 – 12:00, Room: Crestone A

Session Chair: *Rune Schlanbusch – Teknova AS*

As oil companies race for cost reduction, considerable work is invested in automatizing the process of drilling and production. One of their goals is to minimize the offshore crew and replace it with small crews in operations centers controlling the installations from land. Condition based maintenance is seen as an important topic towards realizing offshore autonomy without hampering risk. For efficient development, equipment groups have to be identified which leads to the most necessary and cost efficient results. The chosen monitoring technology must have strict requirements with respect to reliability and need rigorous documentation, for fitting the acceptable risk levels within the industry. Current challenges include no clear standardization and IT security.

*Panelists:*

*Joseph Thorp, ARAMCO*  
*Rune Schlanbusch, Teknova AS*  
*Neil Eklund, Schlumberger*  
*Gilbert Chahine, National Oilwell Varco*

### Panel Session 4: Automotive PHM and Advanced Analytics

Tuesday, 1:15 – 3:00, Room: Crestone A

Session Chair: *Steven W. Holland – General Motors*

PHM technology has entered production use in the automotive domain and is expected to become increasingly important for 1) Advanced Diagnostics and 2) True Prognostics. The scope of this panel includes the opportunities and barriers to the growth of PHM for commercial and, possibly, fleet applications. This panel is highly qualified to address the critical role suppliers will need to play in collaboration with the OEMs/Integrators to maximize the value to themselves but more importantly to the end customer. The power of Advanced Analytics further expands the scope and illustrates the paradigm shifting nature of the opportunity before us.

*Panelists:*

*Yilu Zhang, General Motors*  
*Barry Einsig, CISCO*  
*Tim Felke, Honeywell*  
*Mohak Shah, Bosch*  
*Mircea Gradu, Hyundai*

### Panel Session 5: PHM Education & Professional Development

Tuesday, 3:30 – 5:15, Room: Crestone A

Session Chairs: *Jeff Bird – TECnos, Karl Reichard – Penn State*

Successfully implementing PHM technologies across diverse sectors requires practitioners with multi-disciplinary knowledge and complex applications experience. The academic sector provides the bases in various specialties through degrees, certificates and short courses. Are these tools good enough to convince asset managers to develop and implement impactful PHM solutions? The PHM Society has proposed a PHM Taxonomy to define the skills and mastery levels. In addition, the Society has proposed a Continuing Professional Development scheme to guide practitioners, employers and educators.

*Panelists:*

*George Vachtsevanos, Georgia Tech*  
*Greg Kacprzynski, Impact Technologies/Sikorsky, A Lockheed Martin Company*  
*Ravi Rajamani, dr<sup>2</sup> Consulting*  
*Kai Goebel, NASA*  
*Lacklan Astfalck, University of Western Australia*

### Panel Session 6: PHM Standards Experience for Manufacturing

Wednesday, 8:45 – 10:15, Room: Crestone A

*Session Chairs: Jeff Bird – TECnos, Ravi Rajamani – drR<sup>2</sup> Consulting*

This panel sets the stage for beginning the PHM Society community's conversation with respect to the standards needs and wants of manufacturing stakeholders. The panel's goals are to: understand the contributions and development needs for information, guidelines and standards for PHM technologies in the aerospace sector; and how these could be the basis for other sectors, particularly the complex domain of manufacturing. First to introduce the needs and opportunities for PHM contributions to in the manufacturing sector. Then to show how information documents, recommended practices and standards have been developed systematically, for example, under SAE International HM-1 for the aerospace sector. Finally, to discuss the management of this development, and implementation process from the point of view of SAE International. Then with the audience, to identify key needs and development processes in preparation for the following Smart Manufacturing Panel.

*Panelists:*

*Brian A. Weiss, NIST  
Ravi Rajamani, drR<sup>2</sup> Consulting  
Logen Johnson, SAE International*

### **Panel Session 7: Smart Manufacturing PHM**

Wednesday, 10:30 – 12:00, Room: Crestone A

*Session Organizer: Brian A. Weiss – NIST*

As manufacturing environments become more complex, fault and failure opportunities increase throughout the factory. Manufacturing complexity can stem from many factors including greater flexibility and reconfigurability in manufacturing processes (to leverage new technology and/or support product customization). This complexity forces manufacturers to assess and re-assess areas of risk within their manufacturing processes. Those areas of greatest risk often become ideal targets for PHM. Including PHM (i.e., condition monitoring, diagnostics, and prognostics) can increase operational efficiency and decrease downtime. This panel both builds on the discussions of the experience and processes from the Standards Experience for Manufacturing Panel and highlights some specific challenges, needs, and wants with respect to the development and implementation of standards and guidelines with respect to PHM. This diverse group of panelists present their standards and guidelines perspectives on PHM within Smart Manufacturing. Conversations will include PHM's current and envisioned applications within factory environments along with how the needs, data stream, and supporting PHM tools, can be better designed, developed, implemented, verified, and validated to impact smart manufacturing.

*Panelists:*

*David Siegel, Predictrionics  
Tom Bugnitz, Manufacturer's Edge  
Al Salour, Boeing  
Joel Niedig, ITAMCO*

### **Panel Session 8: Railway PHM**

Wednesday, 1:15 – 3:00, Room: Cripple Creek B

*Session Chair: David Siegel – Predictrionics*

The maintenance strategies for rolling stock, railway infrastructure, and signaling equipment for the railway industry are moving towards a more predictive and condition based maintenance approach. With the advances in sensors, data and network infrastructure, and advanced data analytics, the railway industry has made great strides in realizing predictive maintenance offerings and has the ability to further extend these offerings in the near future. There are numerous examples of predictive maintenance for infrastructure (track geometry/rail condition, point machines), rolling stock

(brake pads, diesel engines, traction motors, wheel health, real-time monitoring /event analysis), and the panelist will discuss some of these current efforts. In addition, the panelist will discuss the current challenges (both business and technical) for developing and deploying PHM technologies in the railway industry. Lastly, some thoughts on the future direction of PHM and data analytics for the railway industry will be discussed from both the panelist and the audience members.

*Panelists:*

*Parham Shahidi, PARC  
Yan Liu, National Research Council Canada  
Pierre Dersin, Alstom Transport  
Zachery Gardner, VisioStack  
Milan Karunaratne, GE Transportation*

### **Panel Session 9: Department of Defense (DoD) Condition Based Maintenance Plus (CBM+) Service Panel Review**

Wednesday, 1:15 – 3:00, Room: Crestone A

*Session Organizers: Andy Hess – The Hess PHM Group, Greg Kilchenstein – Office of Secretary of Defense for Maintenance, Dave Cutter – Logistics Management Institute, Debbie Lili – NCMS*

A panel of Service leaders from across the Department will showcase their evolving Condition Based Maintenance Plus (CBM+) capabilities. The panelists will summarize the challenges and benefits experienced while identifying, developing, implementing, and maturing the Services' approaches to improve weapon system sustainment. This discussion will share best practices and highlight the enabling tools and technologies that are driving increased operational readiness and reduced logistics cost through more effective maintenance practices.

*Opening Keynote Address:*

*Kevin Bostick, Army AMC Deputy G3/4 for Logistics Integration*

*Panel Moderator:*

*Greg Kilchenstein, Director, Enterprise Maintenance Technology, Office of Secretary of Defense for Maintenance*

*Panelists:*

*Dave Pack, Army G-44(M) CBM+ Program & Field Maintenance  
Debora Naguy, Air Force AFLCMC Product Support Engineering  
Marc Borkowski, NAVSEA 04RM Maintenance Engineering  
Dwayne Cole, NAVAIR CBM+ Enterprise Team*

### **Panel Session 10: Select Military Maintenance Projects Funded through the Commercial Technologies for Maintenance Activities (CTMA) Program**

Wednesday, 3:30 – 5:15, Room: Crestone A

*Session Organizers: Andy Hess – The Hess PHM Group, Greg Kilchenstein – Office of Secretary of Defense for Maintenance, Dave Cutter – Logistics Management Institute, Debbie Lili – NCMS*

A panel consisting of industry maintenance providers will present the technology projects that have been funded and developed to address specific maintenance challenges across the Department of Defense (DoD). The panelists will discuss the development of their projects from the initial requirement and resourcing to prototyping and fielding. The scope of technologies being presented will include intermittent fault detection, maintenance inspection automation, task performance visualization, and big data analytics. This discussion will show how maintenance activities and industry participants can leverage the CTMA collaborative agreement between the DoD and the National Center for Manufacturing Sciences (NCMS) to develop critical maintenance capabilities not otherwise available. Additional project information is available at the CTMA booth in the exhibit hall.

Panel Moderator:

Debbie Lilu, Commercial Technologies for Maintenance Activities  
Program Director, National Center for Manufacturing Sciences

Panelists:

Michelle Dickey, SAS  
Ken Anderson, Universal Synaptics  
Patrick Henning, Spectro, Inc.

### Panel Session 11: Big Data Analytics

Thursday, 8:45 – 10:15, Room: Crestone A

Session Chair: Jonathan Bednar – Boeing

Session Organizer: Greg Bower – QorTek

Performing PHM at its basic core is collecting and analyzing data looking for and identifying trends and features that can be used to determine system health. Accomplishing PHM requires data from many different sources and thus leading data derived/driven approaches into the 'Big Data' paradigm. The Internet of Things (IoT) is an example that is fast becoming a vast land of 'Big Data' ripe for processing. A necessity is thus to efficiently process and mine the data.

The panelists in this session will describe approaches used to efficiently process 'Big Data' in order to produce the attributes necessary for successful PHM. Current and state of the art analytic approaches will be discussed based upon the experiences of the panelist and audience. In addition, the application of cloud based computation will be discussed. Applications of discussed approaches will also be included and audience participation will focus on other potential applications and approaches.

Panelists:

Gregory Ditzler, University of Arizona  
Seth Deland, MathWorks  
Bill Nieman, General Electric  
Bill Roberts, SAS  
Neil Eklund, Schlumberger

### Panel Session 12: Fielded Systems

Thursday, 1:15 – 3:00, Room: Crestone A

Session Chairs: Andy Hess – Hess PHM Group, Brian A. Weiss – NIST

Much can be learned from the requirements generation, development, Verification and Validation, implementation, maturation, fielded use, and fleet support of real world PHM systems. Just the development of the individual capabilities that make up a comprehensive and fully integrated PHM system; provides a large number of lessons learned - both good and bad. These need to be discussed, documented, and viewed across the many industry sectors that are fielding PHM systems.

Panelists:

Steve Holland, GM  
Tim Felke, Honeywell  
Pate Carini, UTAS

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## Keynote Speakers

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### Keynote #1: Trends and Recent Advances of Industrial Big Data Analytics and Cyber Physical Systems for PHM Applications

Monday, 1:00 – 1:45

Room: Crystal Ballroom

Dr. Jay Lee

University of Cincinnati

Abstract: In today's competitive business



environment, companies are facing challenges in dealing with big data issues for rapid decision making for improved productivity and business innovation. Many product and manufacturing systems are not ready to manage big data due to the lack of smart analytics tools. U.S. has been driving the Cyber Physical Systems (CPS), Industrial Internet, and Advanced Manufacturing Partnership (AMP) Program to advance future manufacturing. Germany is leading a transformation toward 4th Generation Industrial Revolution (Industry 4.0) based on Cyber-Physical Production System (CPPS). It is clear that as more predictive analytics software and embedded IoT are integrated in industrial products, predictive technologies can further intertwine smart IoT to predict product performance autonomously and further optimize the smart service systems.

The presentation will address the trends of predictive big data analytics and CPS for future industrial PHM application. First, predictive analytics and Cyber-Physical System (CPS) enabled industrial systems will be introduced. Second, advanced predictive analytics technologies for self-aware industrial systems with case studies will be presented. Finally, business innovation based on industrial big data will be introduced using case studies.

*Speaker Bio:* Dr. Jay Lee is Ohio Eminent Scholar, L.W. Scott Alter Chair Professor, and Distinguished Univ. Professor at the Univ. of Cincinnati and is founding director of National Science Foundation (NSF) Industry/University Cooperative Research Center (I/UCRC) on Intelligent Maintenance Systems ([www.imscenter.net](http://www.imscenter.net)) which is a multi-campus NSF Industry/University Cooperative Research Center which consists of the Univ. of Cincinnati (lead institution), the Univ. of Michigan, Missouri Univ. of S&T, and the Univ. of Texas-Austin. Since its inception in 2001, the Center has been supported by over 85 global companies including P&G, GE Aviation, Eaton, National Instruments, Boeing, GM, Ford, Chrysler, Toyota USA, Siemens, Parker Hannifin, Spirit AeroSystems, Ingersoll Rand, Intel, Applied Materials, Lam Research, Bosch Rexroth (Germany), Alstom (France), Omron (Japan), Nissan (Japan), Tekniker (Spain), FMTC (Belgium), Kistler (Switzerland), Samsung (Korea), Shanghai Electric (China), SANY (China), Baosteel (China), HIWIN (Taiwan), Foxconn (Taiwan), etc. He is the pioneer on Industrial Big Data and has authored the book "Industrial Big Data" which has been a top selling book. He was selected as 30 Visionaries in Smart Manufacturing by SME in 2016.

His current research focuses on Industrial Big Data Analytics, Cyber Physical Systems, and Self-Aware Asset Management Systems. He is one of the pioneers in the field of Intelligent Maintenance Systems, Prognostics and Health Management (PHM), as well as Predictive Analytics of Asset Management. He as mentored his students and won 1st prize of PHM Data Challenges five times since 2008. He also mentored his students and developed a spin-off company Predictronics through NSF ICorps Award in 2012. Currently, he serves on the Advisory Board for a number of start-up companies including Predictronics and Falkony, etc.

He was invited to be a member of White House Cyber Physical Systems (CPS) American Challenge Program in Dec. 2013, a member of Technical Advisory committee (TAC) of Digital Manufacturing and Design Innovation (DMDI) in Feb. 2014, as well as a member of Leadership Council of MFOresight which is a NSF/NIST Newly established manufacturing Think Tank in Sept. 2015.

He serves as a senior advisor to McKinsey & Company as well as a S&T advisor to Alstom Transport, France. In addition, he serves on the Board of Governors for Frost Sullivan Manufacturing Leadership Council, SME Smart Manufacturing Digital Transformation Executive Committee, Scientific Advisory Board of Flanders' MECHATRONICS Technology Centre (FMTC) in Leuven, Belgium, Scientific Committee of SIMTech of Singapore, etc. He also serves

as honorary professor and visiting professor for a number of institutions including Shanghai Jiao Tong Univ., Cranfield Univ. in UK, Lulea Univ. of Technology in Sweden, etc. In addition, he serves as editors and associate editor for a number of journals including IEEE Transaction on Industrial Informatics, Int. Journal on Prognostics & Health Management (JPHM), Int. Journal on Service Operations and Informatics, etc.

Previously, he served as Director for Product Development and Manufacturing at United Technologies Research Center (UTRC), E. Hartford, CT as well as Program Directors for a number of programs at NSF during 1991-1998, including the Engineering Research Centers (ERCs) Program, the Industry/University Cooperative Research Centers (I/UCRCs) Program, and the Div. of Design, Manufacture, and Industrial Innovation. He also served as an advisory member for a number of institutions including, Johns Hopkins Univ., Cambridge Univ., etc.

He has authored/co-authored numerous highly influential articles and technical papers in the areas of Prognostics and Health Management, E-Manufacturing, Industry 4.0, and Cyber Physical Systems in Manufacturing, etc. He has over 20 patents and trademarks. He is a frequently invited speaker and has delivered over 300 invited speeches worldwide including over 200 keynote and plenary speeches at major international conferences. He is a Fellow of ASME, SME, as well as a founding fellow of International Society of Engineering Asset Management.

He has received a number of awards including the most recent Prognostics Innovation Award at NI Week by National Instruments in 2012 and NSF Alex Schwarzkopf Technological Innovation Prize and MFPT (Machinery Failure Prevention Technology Society) Jack Frarey Award in 2014.. He is also a honorary advisor to the Heifer International-a charity organization working to end hunger and poverty around the world by providing livestock and training to struggling communities.

### **Keynote #2: The Role of PHM at Commercial Airlines**

Tuesday, 12:00 – 1:15

Room: Crystal Ballroom

Rhonda Walthall

UTC Aerospace Systems

*Abstract:* As profit margins at commercial airlines in the United states approach levels typically seen in other industries, the airlines are starting to invest in processes that will improve operational efficiencies, improve customer satisfaction, and reduce direct operating costs. The supply of Data Analytic companies offering the capability to the provide business insight to achieve these goals is endless. With modern aircraft producing a terabyte of data on every single flight, smart sensors being installed on more and more components, and the Internet of Things ensuring more connectivity, how will the airlines use this information to achieve their operational goals? What information do they really need? Are they willing to pay for the insight?

In this presentation, Rhonda will discuss the current state of the commercial airlines, what their cost drivers are, and how PHMs can be used to lower their costs and improve their operations, assuming they are willing to pay for it.

*Speaker Bio:* Rhonda Walthall is the Manager of Prognostics and Health Management at UTC Aerospace Systems. Since 2010, she has led the development and implementation of the Aircraft System Health Management (ASHM) Program. Prior to joining UTC in 2003, she worked for Northwest Airlines and McDonnell Douglas Aircraft Company.



Rhonda is a member of SAE International and the 2016 recipient of the James M. Crawford Technical Standards Board Outstanding Achievement Award. She is the current Chair of the newly formed Reliability, Supportability, and Health Management Systems Group, the Integrated Vehicle Health Management (IVHM) Steering Group, and the 2016 Fellows Selection Committee. She is an active member of the E32 Committee for Propulsion Systems Health Management and the HM-1 Committee for Health Management.

Rhonda was an author and contributor to the SAE publications "Integrated Vehicle Health Management: Implementation and Lessons Learned" and "Integrated Vehicle Health Management: Business Case Theory and Practice." She was a presenter in the SAE webcast "Taking Data to New Heights: How Airlines, Plane Manufacturers, and Suppliers Are Shaping the Future of Integrated Vehicle Health Management." She served as the Document Sponsor for multiple Aerospace Information Reports.

Rhonda is an active member of the Prognostics Health Management (PHM) Society, Toastmasters International, and Women in Aviation International. Rhonda holds one patent and two invention disclosures.

Rhonda received her Bachelor of Science Degree in Aeronautical and Astronautical Engineering from Purdue University and a Master's Degree in Business Administration from Pepperdine University.

### **Keynote #3: Testing and Debugging Software-Intensive Systems**

Thursday, 8:00 – 8:45

Room: Crystal Ballroom

Dr. Rui Abreu

PARC



*Abstract:* Although considerable effort has been invested in developing methods for testing and failure detection, synthesis of programs from abstract models and verification of programs (and models), techniques for locating the root cause of observed program failures are still relatively immature. Therefore, the utility for general testing and debugging techniques remain limited to specific programs, execution environments, and problem contexts. Furthermore, no plug&play toolset exists providing state-of-the-art techniques to help developers with testing and debugging.

In this talk, we will discuss current state-of-the-art techniques for testing and debugging and how the combination of all these techniques helps to gain a better understanding of the software application. The techniques discussed in the talk are available within a plugin for the Eclipse IDE, coined GZoltar.

*Speaker Bio:* Dr. Rui Abreu holds a Ph.D. in Computer Science - Software Engineering from the Delft University of Technology, The Netherlands, and a M.Sc. in Computer and Systems Engineering from the University of Minho, Portugal. His research revolves around software quality, with emphasis in automating the testing and debugging phases of the software development life-cycle as well as self-adaptation. Dr. Abreu has extensive expertise in both static and dynamic analysis algorithms for improving software quality. He is the recipient of 5 Best Paper Awards, and his work has attracted considerable attention. He is currently a member of the Model-Based Reasoning group at PARC's System and Sciences Laboratory.

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## Luminary Presentations

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The Luminary sessions are tagged as a keystone event for the 2016 PHM Conference. In these sessions, experts from different domains provide new insights on the pervasive use of health management methods and technologies. In 2016, the luminary session will take place on the mornings of Tuesday, October 4 and Wednesday, October 5. These sessions are intended not only to highlight the inter-disciplinary aspect of health management, but also promote an interchange of ideas that span diverse application domains.

### Luminary Presentation #1: Dealing with Disaster in Space and on Earth

Tuesday, 8:00 – 8:45

Room: Crystal Ballroom

Dr. David C. Hilmers

Baylor College of Medicine



**Abstract:** The Challenger accident on January 28, 1986 resulted in the first loss of life during a NASA manned spaceflight. The events leading up to this tragedy, the lessons learned, and my experiences as a crewmember on the return to flight mission will be discussed. After retirement from NASA and the Marine Corps, I completed medical school, residency, and became a professor at the Baylor College of Medicine in Houston, Texas. My experiences as a physician in an Ebola treatment unit in Liberia during the recent outbreak in West Africa will be described as well as current research on the prevention of and rapid response to new epidemics. The similarities of working in the remote environments of outer space and resource-poor countries will be highlighted.

**Speaker Bio:** Dr. Hilmers is a Professor in the Departments of Internal Medicine and Pediatrics, the Center for Space Medicine, and the Center for Global Innovation at the Baylor College of Medicine in Houston, Texas. He is board certified in both internal medicine and pediatrics. In addition to teaching, his clinical pursuits have included international HIV, pediatrics special needs, adolescent medicine, aerospace medicine, emergency medicine, tropical medicine, nutrition, and inpatient internal medicine. His research interests include aerospace medicine, refugee health, micronutrient deficiencies, food fortification programs, disease outbreaks such as Ebola, and the influence of malnutrition on infectious diseases such as HIV and malaria. He has done international volunteer service and disaster relief work in over 50 countries and recently spent two months treating patients in an Ebola Treatment Unit in Liberia. Prior to entering medical school at the age of 42, he was a Marine Corps colonel, aviator and electrical engineer and served as a NASA astronaut on four space shuttle missions, including the first after the Challenger accident.



### Luminary Presentation #2: Diagnostics with a Noisy Sensor: From Aircraft to Player Performance

Wednesday, 8:00 – 8:45

Room: Crystal Ballroom

Dr. Daniel Mack

Kansas City Royals



**Abstract:** The knowledge and experience gained in Dr Mack's projects in Diagnostics

and Anomaly Detection for Aircraft provided a unique look at player performance analytics, that goes beyond the data-driven tools used. In this talk, Dr Mack will discuss a bit about a domain transformation that is inspired from the diagnostics work, and what the future might hold for sports analytics in this mold. With that link in place, Dr Mack will then touch upon how he would bring information back across that transformation into PHM.

**Speaker Bio:** Dr. Daniel Mack enters his fourth season with the Royals and second with the title of Director of Baseball Analytics/Research Science, being promoted on January 5, 2015. He was originally hired by the organization in 2013 as an Analyst in Baseball Analytics. Mack works closely with the Baseball Analytics staff to assist with quantitative research and development of analytics in support of all areas of Baseball Operations. Prior to accepting the job with Kansas City, Mack obtained a doctorate in Computer Science from Vanderbilt University. At Vanderbilt, Mack's dissertation focused on Machine Learning and Anomaly Detection. While pursuing his doctorate, Mack worked as a research assistant at the Institute for Software Integrated Systems where he and his research group won the NASA Associate Administrator Award for Technology and Innovation for work combining machine learning with fault diagnosis. He was also a teaching assistant while completing his master's degree in computer science with a concentration in machine learning at Columbia University in New York. Mack graduated with a bachelor's degree in computer science from the University of Notre Dame in 2006. A native of Reno, Nev., he resides in Kansas City, MO.

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## Social Program

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### Sponsor Exhibits

Monday – Thursday, Location: Crystal Ballroom Foyer

### Welcome Reception

Monday, 5:30 – 7:30, Location: Crystal Ballroom Foyer

### Poster Reception

Tuesday, 5:30 – 7:30, Location: Crystal Ballroom

### PHM Conference Banquet

Wednesday, 6:00 – 9:30, Location: Sports Authority at Mile High Stadium (for guest tickets, please see Registration Desk)



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## Poster Presentations: Tuesday 5:30 – 7:30

### Location: Crystal Ballroom

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#### Doctoral Symposium Posters

- Circuit Breaker Health and Reliability Monitoring: The Key to Realizing a Smarter Electricity Grid — Payman Dehghanian, *Texas A&M University*  
Algorithms for Hybrid Diagnostics of Nonlinear Systems — Turki Haj Mohamad, *Villanova University*  
Fault-Tolerant Supervisory Control Mechanism for Chiller Plants — Khushboo Mittal, *University of Connecticut*  
Bayesian Cramér-Rao Bounds for Time-of-Failure Probability Mass Function Estimation — David Acuña, *University of Chile*  
Development of Deep Learning Based Approaches for Rotating Machinery Fault Diagnosis with Big Data — Miao He, *University of Illinois at Chicago*  
Model-Based Failure Prognosis Approach for Complex Systems to Support Asset Management — Olivier Blancke, *École de Technologie Supérieure*  
Toward Battery Health Management for Small-size Battery-powered Rotary-wing Aircraft — Gina Sierra, *University of Chile*  
Deep Learning based Diagnosis of Journal Bearing Rotor Systems — Joon Ha Jung, *Seoul National University*  
Probabilistic Pipe Strength and Toughness Estimation through Information Fusion with Bayesian Updating — Sonam Dahire, *Arizona State University*  
Meta Learning for Fault Tolerant PHM Systems Considering Correlated Failures — Saikath Bhattacharya, *University of Massachusetts Dartmouth*

#### PHM2016 Posters

- Used Lubricating Oil Filter Debris Analysis (FDA) for Problem Diagnostic of Oil Lubricated Machinery — Dongjin Kim, Seok-Goo Kim, Jaewook Lee, Hwa Seob Song, Sang Hui Park, Joo-Ho Choi  
Prognostics Data Library – developments since the European PHM conference — Joanna Sikorska, Melinda Hodkiewicz, Ashwin D'Cruz, Lachlan Astfalck, Michael Stewart, Adrian Keating

#### DX-2016 Posters

- On Diagnosis of Violations of Constraints in Petri Net Models of Discrete Event Systems Using Fourier-Motzkin Method — Ahmed Al-Ajeli, Behzad Bordbar  
Abductive Diagnosis Based on Modelica Models — Bernhard Peischl, Ingo Pill, Franz Wotawa  
Semantics Enabled Standardized User Interfaces for Diagnosis in Modular Production Systems — Andreas Bunte, Alexander Diedrich, Oliver Niggemann  
Deriving Minimal Hitting-Sets for Linear Conflict Sets — Xiangfu Zhao  
Remote Fault Diagnosis of Robots Using a Robotic Black Box — Ahmad Drak, Youssef Youssef, Paul Plöger, Anastassia Kuestenmacher  
Anticipatory Troubleshooting — Netanel Hasidi, Roni Stern, Meir Kalech, Shulamit Reches  
Comparison of Compilation Based Diagnosis Approaches: OBDD vs DNNF — Wenfeng Zhang, Bo Pang, Qi Zhao, Gan Zhou, Xiumei Guan, Wenquan Feng  
Belief Management using the Action History and Consistency-Based-Diagnosis — Clemens Mühlbacher, Gerald Steinbauer  
Water Management in a Peri-Urban Region in India: Designing a Model Library for Process-oriented Diagnosis and Decision Support — Peter Struss, Franziska Steinbruch, Christoph Woiwode  
Definition of Model-based Diagnosis Problems with Altarica — Yannick Pencolé, Elodie Chanthery, Thierry Peynot  
Dynamic Clustering as a Tool for Monitoring Evolving Systems — Nathalie Barbosa Roa, Louise Travé-Massuyès, Victor Hugo Grisales Palacios  
Unification of Leaky Noisy OR and Logistic Regression Models and Maximum A Posteriori Inference for Multiple Fault Diagnosis Using the Unified Model — Ali Abdollahi, Krishna Pattipati  
Sequential Scheduling of Observations in Diagnosis of Continuous Dynamic Systems — Roberto Zanotti, Alexander Feldman, Marina Zanella, Johan de Kleer  
Sequential Plan Recognition — Reuth Mirsky, Kobi Gal, Roni Stern, Meir Kalech

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## Sincere Thanks to All Review Managers and Reviewers

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# ***PHMAP 2017 Asia Pacific Jeju, Korea, July 12 – 15, 2017***



First Asia Pacific Conference of the Prognostics and Health Management Society  
Organized with the Korean Society for Noise and Vibration Engineering  
Ramada Plaza Jeju Hotel, Jeju, Korea

[www.phmap.org](http://www.phmap.org)

**Volunteers  
Needed!**

PHM 2017 Planning Meeting:  
Thursday, October 6<sup>th</sup>  
10:30 – 12:00  
Crestone A



# ***PHM 2017 St. Petersburg, FL, October 2 – 5, 2017***



Ninth Annual Conference of the Prognostics and Health Management Society  
Hilton St. Petersburg Bayfront Hotel, St. Petersburg, Florida

[www.phmsociety.org](http://www.phmsociety.org)

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 	<p><b>UREASON INTERNATIONAL</b> is an Anglo-Dutch company headquartered in Delft, Netherlands, with offices in the UK, France, Germany and the United States. Recognised as a leader in real-time reasoning engines and predictive analytics, UReason provides software products and services for creating intelligent applications that automate reasoning.</p> <p>This technology enables domain experts – such as operators, process engineers, quality control managers and consultants – to easily create user-friendly, interactive decision-support solutions.</p> <p><b>D2K Technologies (D2K)</b> is a software solution provider dedicated to designing, implementing, testing, validating, and maintaining applications that employ model-based reasoning and machine intelligence technologies for the purposes of delivering improved situational awareness, autonomous control, and knowledge-based decision support. More specifically, the D2K Engineering team has over 30 years of domain experience applying these technologies to Autonomous Operations (AO) and Prognostics and Health Management (PHM) solutions using state of the art expert systems and model-based reasoning platforms. D2K is actively working on autonomous operations projects on behalf of DoD and NASA.</p>

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	<p><b>Commercial Technologies for Maintenance Activities (CTMA)</b> 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&amp;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.</p>



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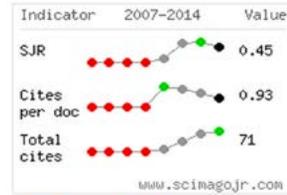


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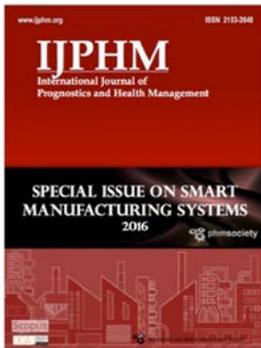
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- Diagnosis and Fault Isolation Methods
- Data-Driven & Model-Based Prognostics
- PHM Sensors and Devices
- Fault-Adaptive Control Methods
- Physics of Failure Mechanisms
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- Return-on-Investment Analysis
- Deployed PHM Applications

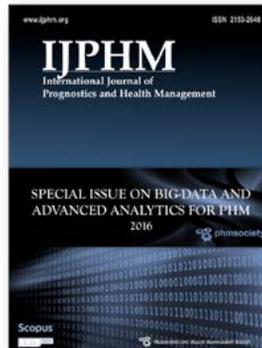
**Let us know if you'd like to be a part of IJPHM team or have an idea for spearheading a special issue... just send us an email!**

## Special Issue Announcements

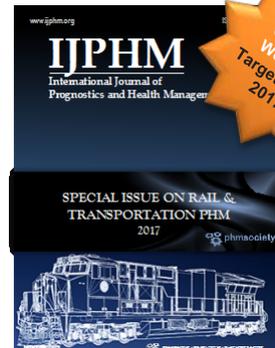
Apart from regular issues, special issues focus on advances in research in condition monitoring applications in specific application domains. CFPs soliciting papers are available from the journal website. A secondary goal is to document and benchmark the state-of-the-art in respective application domains.



PHM for Smart Manufacturing



Big Data & Analytics for PHM



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**CFP on Website Targeted for 2017**

More information is available on the web site: <http://www.ijphm.org>

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