Online Version 2020 UPDATE

The PHM Society offers this updated *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 as <u>an on-line course spread over18 hours over five days</u>. This follows from the first offering at the PHM14 conference in Fort Worth, TX with 48 attendees and regular ratings of 4/5.   It was also run in 2015 in San Diego, 2016 in both Bilbao, Spain and Denver USA, in St. Petersburg, USA in 2017, Philadelphia in 2018, Utrecht, Netherlands in July 2018 and Scottsdale at PHM19.

As in the previous offerings, the course will be taught by recognized international experts in the PHM field and will cover the current state of the art in PHM technologies, sensors and sensing strategies, data mining tools, CBM+ technologies, novel diagnostic and prognostic algorithms as well as a diverse array of application examples/case studies. It is addressed to engineers, scientists, operations managers, educators, small business principals and system designers interested to learn how these emerging technologies can impact their work environment.

Through a lecture (with Q&A), networking and workshop format with specialist experts, participants will:

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

Note: A PHM Society Certificate can be provided for 1.8 Continuing Professional Development Units to each participant completing the course, on request.

Course Leaders: Dr. Karl Reichard and Jeff Bird
Course Presenters: Specialists using proven PHM Society curriculum, case studies and mini-workshops.
Course Administrator: Jeff Bird jeffbird@rogers.com
Course Details:

1. Background reading and references:
    a.   http://www.phmsociety.org/references/documents/recommended-reading
2. Notes will be printed and shipped by participants- see instructions given after you register.
3. Workshop topic: We will work in small groups on small realistic problems: Segment one: developing PHM requirements- needs, stakeholders and metrics and Segment 2- data and modeling approaches, operational issues. Participants are asked to submit a problem statement from their organization: Problem definition, asset of interest, health management objectives, and customer(s).

DAY 1 (ET)	Topic/Format Foundations and Methods	Speaker
100 to 120	Welcome and Introductions (All participants)	Jeff Bird, TECnos
120 to 200	1 Introduction to PHM (Taxonomy, scope, basics, standards- for all talks)	Jeff
200 to 245	2 Deriving Requirements for PHM	Abhinav Saxena, GE
245 to 330	3 Case Study for Requirements/metrics	Abhinav
330 to 345	Break	
345 to 430	4 Diagnostics Methods	José Celaya, Schlumberger
430 to 500	5 Case Study for Diagnostics	José
500 to 515	Wrap-up and Compilation of Issues	All
DAY 2 (ET)	Methods and Project Plan Workshop	Speaker
100 to 145	6 Failure Prognostics	Abhinav Saxena, GE
145 to 210	7 Case Study for Prognostics	Abhinav
210 to 255	8 Data Analytics Methods	Neil Eklund, PARC
255 to 320	9 Case Study for Data Analytics	Neil
320 to 330	Break	
330 to 415	10 Sensors and Sensor Strategies	Karl Reichard, Penn State
415 to 500	11 PHM Project Workshop- Problem, Stakeholders, Metrics (Small group data design activity with worksheets)	All then Breakouts
500 to 515	11 Summary of workshop results (Each group prepares their own results for presentation on Day 3 pm)	Breakouts

DAY 3 (ET)	PHM Business and Plenary	Speaker
100 to 130	11 Summary of workshop results (Each group reports results)	Jeff and Karl
130 to 210	12 CBM+ and IVHM Technologies	Karl
210 to 250	13 PHM Performance Metrics	Abhinav
250 to 255	Short break	
255 to 330	14 PHM Cost Benefit Analysis	Jeff
330 to 415	15 Reliability and Life Cycle Management	José
415 to 445	16 Fielded Systems Case Study for Reliability	José
445 to 450	Short break	
450 to 500	17 PHM Planning Workshop Introduction - Models and Operational Issues (Small group activity builds on workshop 1)	Jeff
500 to 515	Wrap-up and Compilation of Issues	All
DAY 4 (ET)	**Case Studies and PHM Project Workshop**	**Speaker**
100 to 145	18 Fielded Systems Case Study for CBM	Karl
145 to 230	19 Fielded Systems Case Study for Cost Benefit Analysis Bearings	Neil
230 to 245	17 PHM Project Planning Workshop- Models and Operational Issues (Introduction and set up of small group activity)	All then breakouts
245 to 315	17 PHM Project Planning Workshop (Small group activity)	Breakouts
315 to 330	Break	
330 to 415	17 PHM Project Planning Workshop (Small group activity)	Breakouts
415 to 445	17 PHM Project Planning Workshop (Small groups prepare their own report for presentation on Day 5 pm)	Breakouts
445 to 500	Wrap-up	Breakouts
DAY 5 (ET)	**PHM Project Workshop and Plenary Issues**	**Speaker**
100 to 110	Introduction	Jeff
110 to 210	17 PHM Project Planning Workshops review and discussion (Small groups reporting)	All

210 to 315	20 Plenary- Issues and Needs and Priorities (Review to compile collected issues from all participants, then prioritize)	All
315 to 330	Break	
330 to 400	21 Way forward (Paths, Resources, Continuing Professional Development)	Jeff and Karl
400 to 415	Wrap-up 22 Evaluation Forms	All

Presenters

Experienced PHMers will present the tuned PHM Society content and also lead the mini-workshop small group discussions. Interactions are encouraged.

Jeff Bird is currently a consultant with TECnos Consulting Services, Ottawa, Canada. His present avocations include advancing the art, science and business of prognostics and health management in diverse fields. Specifically, he leads PHM Society board initiatives in Education and Professional Development as well as Standards. He recently completed one career spanning 30 years as a Research Officer at the Gas Turbine Laboratory of the National Research Council Canada. His published research there was on gas turbine dynamics and performance, health monitoring and management, adverse environments, and uncertainty. Previously he worked as an Operational Research scientific officer in the Department of National Defence where he enjoyed contributing to airlift and search and rescue planning. He studied at the University of Toronto (Engineering Science- Aerospace) and at Carleton University (Mechanical, Aerospace and Systems).

Dr. José R. Celaya is a Principal Scientist and Machine Learning Technical Lead Manager with the Software Technology Innovation Center, Schlumberger in Menlo Park, CA. He was previously a Research Scientist (contractor) in the Prognostics Center of Excellence and the Diagnostics and Prognostics Group Co-Lead at NASA Ames Research Center. He received a Ph.D. degree in Decision Sciences and Engineering Systems in 2008, a M. E. degree in Operations Research and Statistics in 2008, a M. S. degree in Electrical Engineering in 2003, all from Rensselaer Polytechnic Institute; and a B. S. in Cybernetics Engineering in 2001 from CETYS University, Mexico.

https://www.linkedin.com/in/josecelaya/
https://scholar.google.com/citations?user=RC3TO0EAAAAJ&hl=en

Dr. Neil Eklund, Ph.D. is an experienced technologist in the space of data science, Industrial Artificial Intelligence, machine learning, and evolutionary algorithms for multi-objective optimization, with significant experience in developing fielded solutions to industrial problems. With 20 years of deep technical experience across multiple industry segments – Aerospace, Energy, Healthcare, Finance, Rail, Oil & Gas, and US Government Research (DARPA; NASA, Department of Defense) – he has been the technical lead on a wide range of high-impact projects, resulting in 16 patents, with another four pending, and over 70 technical publications. Dr. Eklund has worked at some of the largest companies in

the world – including General Electric Research and Schlumberger – and also a couple of five-person start-ups. This has allowed him to work on a wide variety of research projects, from early detection of cataract using intraocular photoluminescence to multi-objective bond portfolio optimization. Most recently, his work has focused on fielded, commercially viable asset management systems related to remote monitoring and diagnostics for military and commercial aircraft and oil & gas equipment. He currently works at the Palo Alto Research Centre in data analytics.

Dr. Karl Reichard has over 25 years of experience in the design and development of advanced measurement, control and monitoring systems. He received the Ph.D., M.S. and B.S. degrees in Electrical Engineering from the Virginia Polytechnic Institute and State University (Virginia Tech). Dr. Reichard is a Dr. Reichard is an Associate Research Professor with the Pennsylvania State University Applied Research Laboratory and the Penn State Graduate Program in Acoustics. His research experience includes the development of embedded and distributed sensing and control systems for machinery and system health monitoring, acoustic surveillance and detection, active noise and vibration control and electro-optics. Dr. Reichard is a member of the Board of Directors of the Prognostics and Health Management Society, and a member of the IEEE and the Acoustical Society of America. He is the author of over 50 papers and articles published in journals and conference proceedings.

Dr. Abhinav Saxena is a Senior Scientist in AI & Learning Systems organization at GE Global Research Center. Abhinav is currently involved with developing PHM solutions for various industrial systems at GE and driving integration of PHM analytics in GE's industrial internet platform. Abhinav is also an adjunct professor in the Division of Operation and Maintenance Engineering at Luleå University of Technology, Sweden. Prior to GE, Abhinav was a Research Scientist with SGT Inc. at NASA Ames Research Center for over seven years. Abhinav's interests lie in developing PHM methods and algorithms with special emphasis on data-driven methods for practical prognostics. He has done extensive work on PHM performance evaluation, PHM requirements, and verification and validation of prognostics. He actively participates in several SAE standards committees, IEEE prognostics standards committee, and various PHM Society educational activities, and is a Fellow of the PHM Society. He is also the chief editor of International Journal of Prognostics and Health Management since 2011 and actively participates in organization of PHM Society conferences.