

# PHM Education and Professional Development Panel

## PHM People Panel Nov. 13, 2024

**Welcome and intro:** Jeff Bird (PHM Society and TECnos )

**Ideas and Provocative Questions by panelists**

Prof. Jamie Coble - Univ. Tennessee Knoxville

Dr. Jesse Williams - CTO GTC Analytics

Rhonda Walthall - Senior Technical Fellow Collins Aerospace

Prof. Karl Reichard - Penn State

**Open discussion and Prioritization of Opportunities**

**Moderators: Karl, Jeff and Nancy**

Desired Outcomes

- > Summary of opportunities and gaps
- > Priorities on opportunities

**PHM Society Education and Professional Development Committee**

Jeff Bird, Jamie Coble, Nancy Madge, Karl Reichard and George Vachtsevanos

# PHM Society Role?

## **Society Objectives**

1. Free access to PHM knowledge,
2. Interdisciplinary and international collaboration
3. Advance the engineering discipline

## **Observations**

1. Diverse body of PHM knowledge out there: Standards, lessons learned, information, few case studies
2. Multi-disciplinary awareness and engagement is lacking: Many entrants come from single specialities
3. Continuing professional development is challenging
4. To mature knowledge from theory to practice is challenging: Knowing about relevant knowledge across disciplines, Developing Body Of Knowledge to complement academic training
5. Data and information sharing protocols are essential but problematic: Proprietary and sector specific information

# PHM Society EPD Activities

## Traditional

1. Panels and tutorials at conferences
2. Pre-conference short courses-

## New initiatives

1. PHM EPD Portal: One stop for docs, resources, forum, taxonomy
2. *EPD Users Group and EPD Guidelines*

### **PHM Fundamentals and Case Studies Short Course**

Introduction to PHM

Deriving Requirements for PHM

PHM Performance Metrics

Methods- Diagnostics, Prognostics, Analytics

Case Studies - Methods

Sensors and Processing

Small Group Workshop 1

CBM+ Technologies

PHM Cost Benefit Analysis

Small Group Workshop 2

Fielded Systems Case Studies CBM, CBA

Way forward (you and us)

### **Analytics for PHM Short Course with examples**

Overview of data-driven PHM

Review- Fundamental statistics, Data Visualization

Machine learning - introduction and concepts

Data transformation & Feature Extraction

Methods- Classification and Regression

Introduction to Neural Networks

Hands-on Lab

Feature Selection and Characterizing Performance

Model Selection and Anomaly Detection

Deep Learning I, II and Applications

Practical matters

Hands-on Lab

# PHM Taxonomy- what is the scope of PHM?

A set of capabilities, information and decision-making tools for diagnosis, prognosis and health management of complex systems – Integrating technologies from systems engineering, reliability, analytics

1. System physical modeling
2. Data Modeling
3. Analytics
4. Test and Experimental (Design and conduct)
5. Software Systems
6. Hardware Systems

7. Life Cycle Analysis
8. Verification and Validation
9. Human Factors
10. System Engineering
11. Cost Benefit Analysis
12. Certification
13. Standards
14. Digital Transformation (new)

# Workshop

Prof. Jamie Coble - Univ. Tennessee Knoxville

Dr. Jesse Willams - CTO GTC Analytics

Rhonda Walthall - Senior Technical Fellow Collins Aerospace

Prof. Karl Reichard – ARL Penn State

## Questions guiding the discussion:

1. *What are the opportunities and needs for industry to give back to academia?*
2. *What other opportunities, content and experience would academia like to give to their students?*
3. *What else would industry supervisors wish that new grads arrived with?*
4. *What are the key skills and competencies needed to excel in a PHM career?*
5. *How can students develop these skills while still in college?*
6. *What are the various career paths available in PHM?*
7. *What advice would you give to new graduates entering the PHM field?*

**How could the PHM Society help?**



# Bridging the Gap: Building a Strong Academic Foundation

Jamie Coble  
Professor, Nuclear Engineering



THE UNIVERSITY OF  
**TENNESSEE**  
KNOXVILLE



# *What are the opportunities and needs for industry to give back to academia?*

- \$\$\$
  - Direct funding from industry with defined research direction
  - Collaboration on proposals and projects to guide research direction
- Data / data collection support
- Internship/sabbatical opportunities
  - Internships for students
  - Sabbatical opportunities and support for faculty
- Curriculum support
  - Development- core knowledge expectations
  - Workshops and tutorials from industry
  - Delivery

*What other opportunities, content and experience would academia like to give to their students?*

- Professional mentorship opportunities
  - Build professional networks while in school
  - Undergraduate senior design mentorship
  - Industry professionals on graduate committees
- Accessible short courses or workshops to develop specific skills
- Industry-recognized certificates or credentials



# *What advice would you give to new graduates entering the PHM field?*

- Work on your elevator pitch(es): why, impact, how to solve it, Results
- Think expansively about your expertise and interests
- Find out what resources are available and how to leverage them
- Prepare for the difference between academia and application!

# Notes From Jesse's Talk

- Small business Modis Operandi - maturing technology and handing it off to industry- frequently a university involved
- Frequently involves hiring a student for the process, working with the academic SME
- Lessons learned from working with students
  - Coding skills necessary. Need to know computer science
  - Work through issues. Need to learn how to think holistically
  - Could lead to employment
  - Need students who know how to learn, constantly in that mode
- Think broadly about what PHM means

# Notes From Rhonda's PHM25 and PHME25 Talks-1

- Engineering mode - technical development or management track: Significant opportunities presented to develop either track
- PhDs on research teams
- University interactions: Recruiting at limited number of universities (25), Focus on universities close to their major centers, Hire at all levels- PhDs on research teams, Provide opportunities to further education, Request responses to research problems, Issues with data sharing- need agreements signed, Most hiring mechanical or electrical engineers- only a few aerospace

What are the opportunities and needs for industry to give back to academia?

- I think there is a breakdown between what can realistically be done with PHM in the aerospace industry versus what academia can do with PHM in the theoretical realm. While understanding the theory behind prognostic predictions is extremely important, theory doesn't consider the impact of regulations and access to data. Exposure to regulations at the university level could be quite beneficial. Lack of access to data will become evident as students work with industry to solve problems. Instead of students working with the OEMs (Boeing, Airbus, etc.), I think it would be valuable for students to work with operators (airlines, military, etc.) This opportunity would expose them to regulations, data access, and aging aircraft with different levels of capability. Unfortunately, operators typically do not have the funding to support universities so an alternative funding source would be needed.

What else would industry supervisors wish that new grads arrived with?

- Industry supervisors prefer to hire graduates who have work experience, in particular, Systems Engineering work experience. They also look for teamwork skills and communication skills. Once a student enters the workforce, they will be immersed in a team with each member bringing a different skillset, a different cultural background, and a different working style. The new PHM graduate must know how to communicate what they are working on clearly to the rest of the team.

# Notes From Rhonda's PHM25 and PHME25 Talks-2

What are the key skills and competencies needed to excel in a PHM career?

- A successful career in PHM begins with building the foundational skills in college and then continuously learning new skills after they graduate. Digital Technology moves so fast that the PHM Engineer must practice continuous learning to remain at the leading edge of their chosen field. PHM Engineers must also learn how to work in teams, how to communicate the work they are performing, and how to prepare a proposal with a value proposition. PHM Engineers should be engaged in industry level standards committees to ensure they are driving the direction of PHM in the industry. PHM Engineers should present at conferences, publish papers, books, and journal articles. I recommend joining a Toastmasters Club to build leadership and communications skills and self-confidence.

How can students develop these skills while still in college?

- Students should be adept at using a variety of big data science tools, especially open-source tools. They should be familiar with statistical processes, machine learning techniques and platforms, numerical computing, modeling and simulation techniques, and data visualization techniques. In addition, students must understand how to interpret the data and, most importantly, the results. This means that students should have a fundamental understanding of the physics involved with product they are analyzing. If the student has a passion for aerospace, they should take aero engineering classes to build that foundational knowledge. Hands-on experience working as an intern at an operator would also be valuable.

What are the various career paths available in PHM?

- A data scientist can build a career at any company. A PHM engineer can build a career at any technology company that manufactures products, conducts research, or provides a service. Technology companies offer two career paths: a technical path and a management path. The technical path can be very lucrative and rewarding without the hassle of having to supervise people. The technical career path typically culminates in a Fellows role, which may or may not be considered an Executive, depending on the company. The management path can also be very lucrative and rewarding, but also involves day-to-day management of people and projects. The management career path culminates in a C-suite position, with more opportunities to serve on the board of directors for other companies. Staying in academia is also a career path that can be very rewarding and lucrative. I am not as familiar with the academia career path so I will ask my fellow panelists to comment on this.

What advice would you give to new graduates entering the PHM field?

- Industry is looking for data scientists that understand the latest modeling and simulation technologies, algorithm development, and toolsets. What sets today's graduates apart from the older generation of PHM engineers is that the newer generation enters the workforce with a wide variety of toolsets available to them. They need to understand how to use these tools and how to interpret the results correctly. The older generation of PHM engineers understand the hardware and software better than the newer graduates but lack the skills to use the tools. Both generations need to work together to develop valuable prognostic predictions. My recommendation is to be open to guidance from the older PHM engineers and to be an expert at all the toolsets available to you. I also recommend working for or with an operator to get real hands-on experience with data and regulations.

# Notes From Karl's Talk

- An important ongoing discussion of what academia can do for industry
- Specific courses but a degree in PHM is hard to do at university level because of traditional university structure
- There are a few multi- disciplinary courses- usually graduate level: Requires establishing a base line level across that specific discipline
- One option would be certificate programs, for example data analytics certificates at Penn State starting to be offered within programs
- For PHM if schools start to develop certificate programs in PHM, need exposure to problems in that area and suggestions for courses to address those areas
- Ways to industry involved
  - Provide data, databases as part of data challenges or ways to structure assignments or projects around this data
  - Company could provide problems for students to work on, exposure for students to see what industry needs
  - Provide opportunities for industry to be guest lecturers ( perhaps in conjunction with hiring initiatives
  - Provide students with mixed team, discipline experiences

# Open Discussions

1. Some universities have relationships with industry but they change depending upon the current problem- industry can require a faster solution to a problem than universities can provide, different priorities.
2. Recommend to industry- build internships around the technology. Mentorships and good problem statements help prepare students for work
3. PHM certificates could be based in interdisciplinary departments perhaps[s with short courses
4. Communication and dynamic team work skills for students essential and may be helped with senior design and capstone projects
5. Post doc view- university more interested in cutting edge issues, companies more focused on robust solutions. Project phases:
  1. Basic feasibility , 2. Beta level, 3. ability to commercial possibilities

## Broader Issues

1. PHM has a niche role, not a lot of clout (Might save money or avoid a failure but won't make money) or ability to disseminate data or process to help: How could PHM help with Institutional inertia. Great ideas from conference but difficult to apply at work, need assistance with promoting these ideas , perhaps concrete case studies to help make the point, build linkages with academic domain. Need playbook for ROI/Value proposition issue and/or Cost Benefit Analysis course.
2. Intellectual Property issue across sectors, student-university and lengthy NDA process even for repeat partners. Help in breaking down barriers needed.
3. Data: Ownership and access to data for joint projects. Sometimes difficult for industry to mine data out of their products



# Feedback on Priorities

*Audience: Two votes for your priorities*

**7 votes:** *What are the opportunities and needs for industry to give back to academia?*

**4 votes:** *What other opportunities, content and experience would academia like to give to their students?*

**9 votes:** *What else would industry supervisors wish that new grads arrived with?*

**16 votes:** *What are the key skills and competencies needed to excel in a PHM career?*

**4 votes:** *How can students develop these skills while still in college?*

# Way Forward- Get Involved!

- IJPHM papers and communications
  - Indexed in the Emerging Sources Citation Index
    - Submit an abstract for a paper or a communications
    - Propose a Special Issue
- Updates on EPD in progress
  - *PHM Standards Portal* - [PHM Education and Professional Development Portal - PHM Society](#) as part of the Society community
  - EPD Users Group - join
  - Forum discussions – participate EPD forum: [PHM Education - PHM Society](#)
- What else would be useful?

**Please visit and participate in the PHM24 discussion group on WHOVA**

Thank you

Hope to see you in Singapore in 2025 for PHMAP25 and Bellevue WA for PHM25