





Panel Discussion:

Automotive PHM Emerges

Tuesday, 25 September 2018, 9-10:30 AM EDT Philadelphia, USA, Aria A&B Room

Chair: Steven W. Holland, GM



Today's Agenda

- Purpose & scope of today's panel
- Brief introduction of panelists with their own introductory statements:
 - Limited to 4-6 minutes each
- Audience questions & discussion
 - This is the key part
 - I will try to keep things moving so all have an opportunity to ask questions



Purpose & Scope

- PHM technology has begun to enjoy limited success in the automotive domain for retail customers, fleet customers and shipping providers.
- The business impact achieved, while significant, is projected to rapidly increase as the industry transitions from a private-ownership-centric model to variants of ride sharing with increasing degrees of autonomy. In the newer business models, PHM simply becomes essential.
- This panel will explore the barriers to accelerating the impact of PHM:
 - 1. Awareness of PHM technology and its benefits by business leadership and customers alike,
 - 2. Integration of PHM into the engineering design fabric of the key players, and
 - 3. Effective industry standards & consortia to bring down the costs of implementation.
- Suppliers have always played a critical role in the industry and will be equally critical to the success of PHM.
- PHM demands a strategic approach not only aligned with company goals and product requirements but also linked into its field service support.



Today's Panelists

- Marc Brummer, BMW München, Germany
- Dr. Azeem Sarwar, General Motors USA
- Tim Felke, Honeywell USA
- Tim Schilling, Bosch USA



Steve Holland

- Currently, Research Fellow, Vehicle Health Management at GM Global R&D
- 40+ years of experience at GM in R&D and Manufacturing Eng/Robotics



- Previously R&D Director in Mfging: application of PHM to improve GM plant throughput (4 yrs)
- Currently Chief Technologist: applying PHM technologies to GM vehicles (11 yrs)
- Bachelors/EE from Kettering & Masters/CS from Stanford
- PHM Board of Directors & Member of PHM International Scientific Committee
- SAE Member: HM-1 IVHM Standards & IVHM Steering Committee
- Professional Engineer & IEEE Life Fellow

steven.w.holland@gm.com



Why should automotive accept this scenario if medicine won't? ...PHM is the answer!



September 2018

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Need for Collaboration

- Given the emergence of Automotive PHM, how can OEMs and Suppliers best collaborate to:
 - Speed introduction of PHM functionality for maximum customer/user benefit
 - Maximize system coverage, scalability & accuracy
 - Avoid inefficiencies & wasteful duplication of effort
 - Clarify communication & coordination
 - Ensure data is used as agreed by stakeholders and is secure
 - Respect privacy & regulations relative to owner/operator performance tracking



Supplier Role Crucial for Cost-effective VHM



RATIONALE

This Surface Vehicle & Aerospace Recommended Practice was created to help reduce existing barriers to the successful implementation of Integrated Vehicle Health Management (IVHM) technology into the aerospace and automotive sectors by introducing health-ready components. Health-ready components are augmented either to monitor and report their own health or, alternatively, ones where the supplier provides the integrator sufficient information to accurately assess the component's health via a higher-level system on the vehicle. The principal motivation for health-ready components is to facilitate enhanced IVHM functionality in supplier-provided components that better meet the needs of end users and government regulators in a cost-effective manner. Underlying this motivation is the assumption that market forces will drive the need to achieve IVHM's benefits, which will in turn drive new requirements that suppliers must ultimately meet. This recommended practice has two primary objectives: (1) to encourage the introduction of a much greater degree of IVHM functionality in future vehicles at a much lower cost, and (2) to address legitimate intellectual property concerns by providing recommended IVHM design-time and run-time data specification and information exchange alternatives in an effort to help unlock the potential of IVHM.

https://www.sae.org/standards/content/ja6268_201804/

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Evolution of VHM Capability Levels

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SAE Level	Vehicle Health Capability	Narrative Description	Production Examples				
Manual Diagnosis & Repair Process performed by Technician							
0	Limited On-Vehicle Warning Indicators	Service actions for scheduled maintenance or when Operator notices problems or is alerted by indicator lights or simple gages.	All pre-1980 automotive vehicles				
1	Enhanced Diagnostics Using Scan Tools	Service techs gain added diagnostic insight using automated scanners to extract vehicle operating parameters & diagnostic codes.	Intro of microprocessor- based controls/OBD 1980-1995				
2	Telematics Providing Real- Time Data	Service techs & Engineers gain real-time vehicle data via remote monitoring of vehicle to more completely capture issues.	Introduction of GM OnStar telematic services 1996-2014				
Diagnosis & Repair Augmented by Prognosis & Predictive Analytics							
3	Component Level Proactive Alerts	Operator and service techs are provided with component health status (R/Y/G) before problem occurs. Limited condition-based maintenance.	Introduction of OnStar Proactive Alerts post- 2015				
4	Integrated Vehicle Health Mgmt.	Operator and service techs are provided with system or vehicle level health indicators before problems occur with remaining useful life estimated. Condition-based maint.	Important enabler for future Autonomous & Active Safety Vehicles				
5	Self- Adaptive Health Mgmt.	Self-adaptive control and optimization to extend vehicle operation and enhance safety in presence of potential or actual failures.	Long-range vision				



Emergence of Health-Ready Components

- Data is increasingly becoming "the" critical asset in automotive
 - But raw data can be difficult to use
 - We want to move from
 Data→Information→Insight→Action
- PHM encompasses both the traditional paradigm of diagnostics and the new paradigm of prognostics
- SAE JA6268 lays out the future vision of how suppliers and OEMs can collaborate to mutual advantage to speed the implementation of PHM into automotive arena
- Now is a critical opportunity in time [SAE HRCS SG]





SAE-ITC Website Up, 401-(C)6 Structure

Why SAE ITC

Unlocking the Potential of IVHM Technology

Unlocking the Potential of IVHM Technology

April 6, 2018

New SAE Release: JA6268 Recommended Practice: "Design & Run-Time Information Exchange for Health-Ready Components" was published by SAE on April 2, 2018. This document is designed to help reduce existing barriers to the successful implementation of Integrated Vehicle Health Management (IVHM) technology into the aerospace and

automotive sectors by introducing "health-ready components."

What is a Health-Ready Component? Health-ready components are supplier-provided components or subsystems which have been augmented to monitor and report their own health or, alternatively, those where the supplier provides the integrator sufficient information to accurately assess the component's health via a higher-level system already on the vehicle. *This is key to unlocking the potential of IVHM!*



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Marc Brummer

Marc Brummer received his diploma degree in mechanical engineering in 2007 in Berlin, Germany. Since then he gained his experience on supplier- and OEM-side during function development, calibration and data analytics for embedded systems. His special field is the on- and offboard diagnostic in the automotive sector. In 2011 he joined the BMW Group and works as a project engineer for future diagnostic concepts and PHM for the powertrain.





AUTOMOTIVE PHM EMERGES





Rolls-Royce Mater Can Umited

WHY IVHM: BECAUSE JUST SELLING CARS WILL NOT BE ENOUGH IN THE FUTURE



CURRENT DATA WAS NOT DESIGNED FOR IVHM



HOW TO ENABLE IVHM: COPY -> PASTE METHODS FROM OTHER INDUSTRIES?



CHANGES NEEDED IN TEC, BUSINESS MODEL & -CULTURE TO ENABLE IVHM





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Dr. Azeem Sarwar

Azeem Sarwar received Bachelor's Degree in Mechanical Engineering with highest honors from National University of Sciences and Technology, Pakistan. He received a Master's Degree in Mechanical Engineering, a Master's Degree in Mathematics, and a PhD in Mechanical Engineering from University of Illinois at Urbana-Champaign. After graduating from Illinois, he worked as a Research Fellow at the University of Maryland, College Park, with the Institute of Systems Research. Since 2014, he has been working at General Motors Research and Development Center where he is developing prognostic technologies for automotive applications, and has filed more than 30 Records of Invention, generating 21 patent applications. He is a recipient of the Canadian Commonwealth Scholarship, and the NSF IGERT Fellowships. He has made numerous national and international presentations about his work. His work has featured in one book chapter, three invited journal publications, and more than 25 peer reviewed articles. He is a recipient of IEEE PHM Conference Best Paper Award. His research interests include fault modeling, fault diagnosis and prognosis, machine learning, and artificial intelligence



PHM IN AUTOMOTIVE: NEEDS & CHALLENGES

Azeem Sarwar, PhD

Sept 25, 2018

GENERAL MOTORS

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THE NEED...

Fleet, Retail, Shipping, and Ride Sharing:

• ZERO down time – requirements similar to a manufacturing plant.

Ride Sharing – Paradigm Shift in Transportation



Bates, John, and David Leibling. "Spaced Out: Perspectives on parking policy." (2012).

CHANGE IN DESIGN REQUIREMENTS?

Why Changes?

- Vehicles are typically designed to last 15 years/150,000 miles
- ▶ There are components that experience passive loading as well as active loading



▶ Given how vehicle is used, a component might be over – or under utilized

GENERAL MOTORS

CHANGE IN DESIGN REQUIREMENTS?

How Do we Generate New Requirements?

- Data collection for vehicle usage
- ▶ Partnership with suppliers for
 - ► Design of components in lieu of usage
 - ▶ Health indicators & metrics to assess remaining useful



GENERAL MOTORS

LEADERSHIP AWARENESS

Recent success stories have created a hype about AI and Machine Learning

- Positives: It's forcing the leadership across various businesses to respond every one wants to be part of the fourth industrial revolution!
- Negatives: Many believe that AI and Machine learning is a magic wand which will turn a pile of <u>already available</u> data into value!



 PHM inherently relies on <u>meaningful</u> data that needs to be turned into information, followed by extraction of value from that information

CHALLENGES & OPPORTUNITY

- Educating leadership, not trained in the field of data science, to understand what is possible and what is not (the law of "garbage in - garbage out" still holds)
- A paradigm shift in training and educating the work force at some foundational and functional level of data science and analytics
- A change in mindset at the design level
 - Today we frequently ask: "I have data what can I do with it?"
 - We need to go one step earlier in the process and ask "I want to do X, what data do I need to achieve it ?"
 - Need to think ahead before I get there, how my "there" might look like. This
 would minimize a lot of effort that goes into data preparation

GENERAL MOTORS



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Tim Felke

Tim Felke joined Honeywell in 1984 as a control systems analyst and was the manager for the Systems Analysis and Engineering Sciences department in Tucson AZ for nearly 5 years. He was a principle architect for the Central Maintenance Computer for the Boeing 777 and 787. He then worked for many years on the deployment of IVHM technology for business jets, helicopters and ground vehicles. He was a principle contributor to SAE's JA6268 Recommended Practice for Health Ready Components. He is currently an Engineering Fellow in Honeywell's Connected Vehicles Business working with several automotive OEMs on the design and deployment of IVHM Diagnostic and Prognostic systems.





Tim Felke September 25, 2018

A Supplier Perspective



The Opportunity – PHM Value Through The Life-Cycle

NEEDS	Early Components & System Validation	Product Integrity in All Conditions	Production Conformity	Service Optimization & Customer Satisfaction	Post Warranty Services
OFFERING	Design Consistency	Model Based Anomaly Monitoring	In Plant Monitoring / End of Line Testing	Diagnostics & Predictive Maintenance	Extended Monitoring, Maintenance and
VALUE	Design Validation	More Defects Found / Higher Initial Quality	Production Yield	Warranty Cost Reduction & Customer Retention	Extended Customer Engagement
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	Pre-Development	Product Development S	OP Production	Warranty Period	Extended Use

Honeywell

The Challenges – Obstacles That Limit Results

- For the operator / integrator -
 - DTCs are typically calibrated at levels to minimize false alarms, resulting in many customer complaints with no associated active DTCs.
 - Prognostic functions require much greater accuracy than traditional diagnostic functions.
 - Monitoring/analysis of raw signals is not effective, need to understand difference between measured values and expected values.
 - Subsystems and components contain complex hardware and software that limit the ability to compute expected signal values.
 - Release of required design data to enable PHM is risk to suppliers interest in protecting their IP.
 - Service visits result in high number of "No Trouble Found" part removals.
- For the supplier
 - After initial development, very little data is made available to supplier regarding performance of systems/components.
 - Lack of clarity of true failure modes on vehicle contribute to high No Trouble Found rates.
 - Quality spills are detected much later than possible and potential design improvements are missed.

Honeywell

Proposed Solution -

SAE JA6268: Health Ready Components

- On-Vehicle Software -
 - Additional algorithms are added to the control software to compute and report indicators of key aspects of performance of the Turbocharger and Air System.
 - Algorithms also detect extreme transient events and report them to support computation of accumulated usage.
- Web Services
 - Data from vehicles is downloaded to OEM on periodic basis.
 - Selected subset of data from vehicles is forwarded to Honeywell for analysis, fault detection, usage monitoring and fault predictions.
 - Results are tracked by Honeywell to identify design improvements and are returned to OEM to support customer care and vehicle repair functions.
- Design Data -
 - Honeywell provides design data to the OEM that specify the semantics for the indicators computed by the On-Vehicle Software and Web Services.
 - This data is used by OEM to implement the communications between the Vehicle and Web Services and to use the Results.

Honeywell

Honeywell Transportation Systems will become Garrett

Garrent Advancing motion

Turbo Technology

Our rich portfolio of turbo technologies covers the broadest range of engine applications.

Electric & Hybrid

Increasingly stringent emissions standards require auto manufacturers to develop more efficient solutions.

Connected Vehicles

Our Vehicle Health Management and Cybersecurity solutions help vehicle manufacturers.





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Troy Schilling

Troy Schilling is the Business Development Manager for Connected Services at Robert Bosch, LLC. In this role, he is responsible for leading many of Bosch's efforts in this area. Troy works closely with cross-divisional team members to drive the deployment of the Connected Services product offerings. He has vast experience with Bosch within engineering and business development spanning the transportation, powersports, off-highway and marine industries. Additionally he is a coach within Bosch's Innovation Framework.





Future of Mobility **NEW OFFERINGS, BUSINESS MODELS AND LIFESTYLES WILL EMERGE**





Future of Mobility BOSCH IS SEAMLESSLY CONNECTING MOBILITY





Future of Mobility INCREASING USE OF TECHNOLOGY & INTERNET OF THINGS (IOT)





Future of Mobility BOSCH CONNECTED MOBILITY SOLUTIONS



Today – Vehicle as the central object

Tomorrow – Connected, intermodal transportation services

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Future of Mobility FIRMWARE UPDATES OVER-THE-AIR (FOTA)



Warranty claims significantly reduce the profit margin.

FOTA allows for a **remote update of the vehicle's ECUs** and integrates into existing architectures.

FOTA **saves** compared to a field action.



Future of Mobility **PREDICTIVE DIAGNOSTICS**





No more breakdowns? A car damage occurs always untimely.

Now a new smart data & Albased service, which predicts your car's health constantly while driving.

It informs you – **in time** – about the remaining lifetime for all relevant systems & components.







Step 4

Future of Mobility DATA ANALYTICS – STEPWISE APPROACH TO PREDICTIVE DIAGNOSTICS



Required implementation time



Future of Mobility HOW TO MOVE FORWARD

Bosch is already working on tools for modularization and we recognize a necessity for standardization





We are open to doing a pilot with OEM's to figure out this situation of maintaining IP while offering solutions

www.bosch-iaa.de

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Contact





Selected Thought Starter Questions

- 1. What are the challenges of large scale PHM deployment?
- 2. What are the best practices for OEM/Supplier collaboration?
- 3. How can we avoid duplication of effort between OEMs and Suppliers?
- 4. Importance of Health-Ready Components?
- 5. What strategies will help us avoid IP issues & concerns?
- 6. How to get component & system designers to consider the Prognosis Paradigm and build in the hooks?
- 7. Do fleets need something different than private vehicle owners?
- 8. How can international standards promote the application of PHM?
- 9. Has your management "bought in"? What arguments were effective?
- 10. What fundamental research would you like to see from academia?