Panel Discussion on:

Automotive PHM & Emerging Standards

3-Oct-2017, 1:15-3:00 PM EDT
St. Petersburg, FL

Chair: Steven W. Holland, GM
Today’s Diverse Panelists

• Automotive Suppliers:
  – Andre Kleyner (Delphi)
  – Klaus Sekot (Bosch)

• Automotive OEM:
  – Yilu Zhang (General Motors)

• International Standards:
  – Luis Hernandez (Global Strategic Solutions)
Panel Abstract

• PHM technology has entered production use in the automotive domain and is expected to become increasingly important for:
  – Advanced Diagnostics &
  – True Prognostics

• The scope of this panel includes the opportunities and barriers to the growth of PHM for commercial automotive and 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

• Effective supplier engagement will depend upon emerging standards to reduce proliferation and to manage costs
Panel Format

• Purpose & scope of today’s panel
• Brief introduction of panelists with their own statements:
  – Relevant background & interests (limited to 5-7 minutes each)

→ Audience questions & discussion
  – This is the important part
  – I will try to keep things moving so all have an opportunity to ask questions
Need for Collaboration

• Given the emergence & growing importance of PHM systems across a variety of industries, 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 coordination & communication needs
  – Ensure that data is used as agreed by stakeholders and is secure
  – Respect privacy & regulations relative to operator performance tracking
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 Fellow

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This Aerospace & Automotive 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. The principal motivation for health-ready components is to facilitate enhanced IVHM functionality in supplier-provided components that 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 data specification and exchange alternatives in an effort to help unlock the potential of IVHM.
<table>
<thead>
<tr>
<th>SAE Level</th>
<th>Vehicle Health Capability</th>
<th>Narrative Description</th>
<th>Participation in Repair Actions</th>
<th>Key Data Resources</th>
<th>Availability of Logged &amp;/or Real-Time Data</th>
<th>Use of Supporting Models</th>
<th>IVHM System Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Limited On-Vehicle Warning Indicators</td>
<td>Service actions for scheduled maintenance or when Operator notices problems or is alerted by indicator lights or simple gauges.</td>
<td>Operator/Driver &amp; Service Tech</td>
<td>On-Vehicle Measurements &amp; Observation</td>
<td>N/A</td>
<td>Paper-based Manuals</td>
<td>Only Manual Diagnostic Tools &amp; No Condition-Based Services</td>
</tr>
<tr>
<td>1</td>
<td>Enhanced Diagnostics Using Scan Tools</td>
<td>Service techs gain added diagnostic insight using automated scanners to extract vehicle operating parameters &amp; diagnostic codes</td>
<td>Operator/Driver &amp; Service Tech</td>
<td>On-Vehicle &amp; Service bay/Depot Tools</td>
<td>Logged Diagnostic Codes &amp; Parameters available to Service Tech</td>
<td>Paper-based Manuals</td>
<td>On-Board Diagnostics Available</td>
</tr>
<tr>
<td>2</td>
<td>Telematics Providing Real-Time Data</td>
<td>Service techs gain real-time vehicle data via remote monitoring of vehicle to more completely capture issues</td>
<td>Operator/Driver, Service Tech &amp; Remote Support Center Advisor</td>
<td>On-Vehicle, Service Bay &amp; Cloud Data</td>
<td>Telematic Data Available to Service Tech with Diagnostics Info</td>
<td>Paper-based Manuals</td>
<td>On-Board &amp; Remote Data Available</td>
</tr>
<tr>
<td>3</td>
<td>Component Level Proactive Alerts</td>
<td>Operator and service techs are provided with component health status (R/Y/G) before problem occurs. Limited condition-based maintenance</td>
<td>Operator/Driver, Service Tech &amp; Cloud-Based Services</td>
<td>On-Vehicle, Service Bay &amp; Cloud Data</td>
<td>Telematic Data Available to Service Tech with Diagnostics Info</td>
<td>Addition of Component-Level Health Models</td>
<td>Component-Level Health Predictions</td>
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Integrated Vehicle Health Management (IVHM) capability levels are defined in forthcoming SAE International Standard J5628.

The goal of providing common terminology for Integrated Vehicle Health Management Systems (IVHM systems) is to improve communication and understanding among all stakeholders. The standard defines the following levels:

1. **Baseline:** Basic IVHM system with limited diagnostic capabilities.
2. **Enhanced:** Enhanced IVHM system with improved diagnostic capabilities.
3. **Diagnostic:** Diagnostic IVHM system with advanced diagnostic capabilities.
4. **Predictive:** Predictive IVHM system with predictive maintenance capabilities.
5. **Self-Adaptive:** Self-adaptive IVHM system with self-adaptive maintenance capabilities.

The standard also defines key IVHM system characteristics, such as data availability, diagnostic and repair processes, and the role of diagnostics in failure prevention.

Additional resources can be found at the SAE website: [http://www.sae.org/servlets/works/committeeResources.do?resourceID=570618]
Introducing Today’s Panel

Chair:
  – Steve Holland, General Motors

Panelists:
  – Andre Kleyner (Delphi)
  – Klaus Sekot (Bosch)
  – Luis Hernandez (Global Strategic Solutions)
  – Yilu Zhang (General Motors)
Andre Kleyner, PhD, Certified Reliability Engineer
Global Reliability Engineering Leader,
Delphi Electronics & Safety (Aptiv)

- **Experience 30+ years:**
  Reliability Engineering, Harsh Environments, Accelerated Testing; Warranty data analysis and forecasting, Reliability data analysis, statistics and Monte Carlo simulation; Vehicle occupant safety systems design.

- Editor for the Wiley Series in Quality & Reliability Engineering
  John Wiley & Sons, UK

40 professional publications including three books on the topics of reliability, statistics, warranty management, and lifecycle cost analysis. Including an engineering college textbook
*Practical Reliability Engineering, Ed. 5*
Automotive Electronics Challenges and Prognostics?

- Increasing reliability requirements (15 years mission life and increasing)
- Self-driving cars – new expectations on system reliability and more importantly, safety
- Functional Safety standard – ISO 26262 (13 parts document) covering various aspects of design, safety and reliability
- Long validation testing programs (3-5 months) need to be shortened. Repeat validation testing.
- Limited ability to accelerate the key reliability tests
Interests and Objectives

**Interests**: Explore the applications of prognostics in the Automotive Industry.

**Objective**: Introduce a new application of prognostics in the automotive reliability testing and generate interest in this application in the PHM community. Why? Because it presents interesting and challenging problems and the industry will gladly spend money to get the solutions.
Klaus Sekot

• Director at Bosch Corporate Quality Management responsible for field monitoring and field data
• Previously Corporate Quality Key Account for Daimler, BMW and VW
• 10+ years experience in automotive product development
• Leading plant quality and development business excellent at Bosch plant in Clayton, Victoria (AUS)
• Engineering degree of Heilbronn University - Germany

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QUALITY 4.0
CONNECTED LIFE CYCLE MANAGEMENT
CONNECTED LIFE CYCLE MANAGEMENT

Vision

All products fulfil the requirements of real use

Continuous product control in real use

Reliable Products

Smart Feedback
CONNECTED LIFE CYCLE MANAGEMENT
Value add areas and their benefits

**SPECIFICATION & VALIDATION**
- Product specification and validation based on data out of vehicle in use
- Reduced costs by avoided over-designs
- Early detection of deviation between specification and real use
- Field Load Data Model

**MONITORING & EARLY WARNING**
- Monitoring of known failures in real time and confirmation of their counter measures
- Monitoring of components health state
- Detection of unknown emerging issues

**COMPLAINT & RISK MANAGEMENT**
- Classification of root cause (e.g. NTF)
- Complaint parts handling from dealership to parts investigation point
- Focused analysis of relevant failures
- Support decisions about field campaigns by data

Customer benefits: Cost reduction / quality improvement by avoided over and under-design
Increased vehicle availability and reduced costs for field campaigns
Luis Hernandez

- Managing Director, Global Strategic Solutions LLC
- 30 years experience in diagnostic equipment systems engineering
- 10+ years experience in IVHM/PHM systems applied research
- Leading company’s contribution to SAE HM-1 standards development efforts
- Electrical engineering degree from Wayne State University

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Why Standards?

- Avoid proliferation (OEM) specific technology solutions
- Address data ownership issues
- Enable application of health state data close to operations
- Enable interoperability between solutions
- Stimulate development of advanced technology solutions
- Accelerate time-to-market
Where are we after 15+ Years?

- Commercial Aviation
- Automotive

Diagram shows the progression from manual diagnosis and repair to diagnosis and repair augmented by prognosis and predictive analytics.
Standards Enable the Data Supply Chain

- Integrated data supply chain
- Efficient data acquisition, integration and exchange with enterprise applications
- Data collected across operations and vehicle maintenance activities in standard format
- Preservation of data source context (Values, Meta Data)
- OEM dependence & data ownership resolution
- Efficient processing, correlation, and analysis of data across a fleet
Yilu Zhang

• Technical Fellow and Group Manager of Vehicle Health Management, Vehicle Systems Research Lab at General Motors Global R&D

• Three-time recipient of GM “Boss” Kettering Award, the most prestigious technology award in GM to recognize “stretch thinkers and drivers of innovation”

• Awarded 29 patents, and published 59 papers

• PhD in Computer Science from Michigan State University, MS and BS in Control from Zhejiang University, China

• IEEE Senior Member

Yilu.Zhang@GM.com
— Everything wears out over time
— Customer’s life is disrupted, when his/her vehicle needs repair unexpectedly
— The solution - Vehicle Health Management (VHM)
  • Alert before failure happens
  • Transform an emergency repair to planned maintenance
  • Enhance ownership experience - a delight to customers
— Introducing OnStar™ Proactive Alerts
  - a new customer care service launched in 2015
CHEVROLET: SOLVING ISSUES BEFORE THEY HAPPEN
OnStar Proactive Alerts predict when certain components need attention

Vehicle engineering data is collected with customer consent and free opt-in.

HOW IT WORKS WITH YOUR BATTERY

- Vehicle battery
- Battery conditions sent
- Low battery predicted
- Alert sent
- Issue avoided
Beyond Prognostics – VHM impacts automotive value chain

Supplier  Vehicle development  Manufacturing  Sales  Ownership  Service
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 the academia?