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ADVANCING CAREERS in MAINTENANCE MANAGEMENT

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Constructive Comments Are Always Appreciated!

TMC welcomes your comments, but please make certain that they are constructive and appropriate before you turn in your evaluation sheet!

Thank You for Your Cooperation!
Agenda

• SAE IVHM and the Health-Ready Components and Systems (HRCS) Consortium
  • Pete Grau

• A Supplier View of JA6268 and HRCS
  • Tim Felke

• Wrap-Up & Discussion
  • Pete Grau
IVHM AND THE HEALTH-READY COMPONENTS AND SYSTEMS (HRCS) CONSORTIUM

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2020 Technology & Maintenance Council Conference, Atlanta GA.
FOUNDATIONAL DOCUMENT: SAE JA6268

SURFACE VEHICLE/AEROSPACE RECOMMENDED PRACTICE

Design & Run-Time Information Exchange for Health-Ready Components

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/
SAE AUTONOMOUS VEHICLE IVHM CAPABILITY (VEHICLE LEVEL)
(sources: SAE J3016 & JA6268™)

Illustrating autonomous vehicle capability

Illustrating evolution of diagnosis & prognosis for vehicle maintenance/IVHM capability

| Diagnosis: Determine the root cause of a problem once a failure HAS occurred |
| Prognosis: Predict a potential failure BEFORE it occurs while component is still operating |
HRCS FOCUS: **MOBILITY** (BUT CAN ALSO BE APPLIED TO FIXED-BASE EQUIPMENT)

Current Members:

- Bell Aerospace
- Global Strategic Solutions
- General Motors
- Garrett Motion
- VHM Innovations
- Volvo GTT (Group Trucks Technology)
A SUPPLIER VIEW OF JA6268 AND THE HRCS CONSORTIUM

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2020 Technology & Maintenance Council Conference, Atlanta Georgia.
Integrated Vehicle Health Management (IVHM) Definition and Functionality

Integrated Vehicle Health Management (IVHM) refers to the unified capability of a system of systems to assess current or future state of member system health and integrate that picture of system health within a framework of available resources and operational demand (as defined by SAE's IVHM Steering Committee.)

**IVHM Inputs**
- Asset ID
- Configuration Data
- Mode / State Data
- Usage Data
- Parametric Data
- DTCs
- Time Series Data

**IVHM System**

**IVHM Outputs**
- Accumulated Usage Indicators
- Condition Indicators
- Health Indicators
- Predictive Indicators
- Vehicle Health Status Reports
- Maintenance Alerts
- Material Requirements
- Troubleshooting and Repair Plans
- Warranty Records
- Fleet Analytics
- Service Procedure Content
- Development Test Plan Content

**In Summary:** IVHM provides value by monitoring the health of asset and recommending a (near) optimal sequence preventative and corrective actions.

**IVHM Primary Challenge:** How can we build a system with sufficient accuracy with a cost that is significantly less than the value it provides.
IVHM Value Proposition

**IVHM Costs**

**Build / Maintain IVHM Solution**
- Develop IVHM Hardware
- Develop IVHM Software
- Deploy IVHM Solution
- Deploy Modeling Tools
- Build / Maintain Models

**Execute Maintenance Program**
- Perform Fault Isolation Tasks
- Procure Replacement Hardware
- Perform Fault Preventative Actions
- Perform Corrective Actions

**IVHM Benefits**
- Increase Asset Availability
- Reduce Operational Impact
- Reduce Secondary Damage
- Reduce Material Costs
- Reduce Labor Costs
- Reduce Inventory Costs
- Improve Safety
- Reduce Labor Variability
- Reduce Cost Variability

**IVHM Design Problem Statement:**

*What is the best combination of IVHM functionality that maximizes its lifecycle value vs the costs of implementation?*
Increasing IVHM Value Through Data Standards

The value of current IVHM Systems is limited by cost of covering all significant Failure Modes and integrating the results into operator systems.

Much greater profit across the lifecycle can be achieved through use of standards.
IVHM Implementation Challenge – Find the Degraded Parts

Can you find the bad parts using the available data?

Data is provided:
• Engine RPM
• Ambient Pressure
• Pressure Measured Downstream of Air Filter for 100 vehicles.

Find the ones for which the Air Filters are substantially clogged.

Can you see which ones are outliers?
IVHM Implementation Challenge – Find the Degraded Parts

Can you find them now?
IVHM Implementation Challenge – Find the Degraded Parts

Can you find them now?

RPM

P Ambient

Delta P

Air Flow

P1
IVHM Implementation Challenge – Find the Degraded Parts

Can you find them now?

- RPM
- Delta P
- P Ambient
- Air Flow
- P1
- Resistance = Delta P / Air Flow
Component / System expertise can greatly improve the value of IVHM systems while reducing their cost.

IVHM Implementation Challenge – Find the Degraded Parts

Can you find them now?

It is unlikely that unsupervised Machine Learning could solve this problem just using the sensor data.

Adding system knowledge prior to Machine Learning greatly improves accuracy.

Resistance Deviation $\frac{|x - \mu|}{\sigma}$

Component / System expertise can greatly improve the value of IVHM systems while reducing their cost.
Each supplier must work with dozens of Integrators

Each Integrator must work with hundreds of Suppliers.

Exchange of IVHM Related Design Data and Equipment Status Data

• Suppliers are a critical source of knowledge needed to implement IVHM for the equipment they provide.
• JA6268 was created to simplify the exchange of IVHM related data between Suppliers and Integrators
  • Standardized Exchange of Data from **Supplier to Integrator**: Allows Integrators to build Asset Level IVHM Systems at much lower costs.
  • Standardized Exchange of Data from **Integrator to Supplier**: Allows Suppliers to offer Web-Services for their Components/Systems, to improve Warranty Claim Assessment and to Identify Product Improvements.
JA6268 Improves IVHM Related Communications

JA6268 is a Joint Aerospace and Automotive Recommended Practice Aimed at Reducing the Cost and Increasing the Value of IVHM Systems by Improving Communication Between Suppliers, Integrators and Operators.

**Reduce Cost** by using supplier expertise to monitor, assess and diagnose the equipment they provide.

**Increase Value** by providing standard interfaces to IVHM results to support additional use cases (Route Planning, Maintenance Planning, Material Planning, Asset Value Retention, etc.)
Example Application of JA6268 for Turbocharger

JA6268 is used to standardize run-time messages, web service APIs and design time data submittals.
JA6268 and HRCS Benefit to Commercial Trucking

Each supplier must work with dozens of Integrators

Each Integrator must work with hundreds of Suppliers and dozens of Operators

Each Operator must work with dozens of Integrators

Challenges in Integration of Data Between Fleet Operators and Asset Integrators is Similar to Challenges Faced By Integrators and Suppliers (Need for Semantic Interoperability)
HRCS Accelerates the Adoption of JA6268

• The Health Ready Components and Systems (HRCS) Consortium was created in late 2019 to assist suppliers, integrators and operators in the implementation of JA6268.

• Help Suppliers use JA6268 to standardize IVHM design data submittals and to create compliant web services.

• Help Integrators utilize supplier design data and web services to provide more valuable prognostics, diagnostics, maintenance procedures and support services.

• Help Operators utilize design data to integrate web services into fleet operation and maintenance planning/execution systems.
Benefits to Component / System Suppliers

- HRCS helps suppliers use JA6268 to standardize IVHM design data submittals and to create compliant web services.
- Suppliers provide common JA6268 compliant design data submittals to document compliance with IVHM related requirements.
  - Reduces cost associated with providing different data to each customer.
- Suppliers provide JA6268 compliant web services to convert Component / System status into IVHM results.
  - Provides actual usage and fault related data of equipment to suppliers allowing better product support and design improvement.
  - Compliant web-services can be offered that do not expose critical IP of supplier.
Benefits to Integrators

- HRCS helps integrators utilize supplier design data and web services to provide more valuable prognostics, diagnostics, maintenance procedures and support services.
  - Reduces cost to develop IVHM and After-Sales services
  - Improve Accuracy and Coverage of IVHM and After-Sales services
- Integrator offers compliant services that are more valuable to the operator without loss of IP.
  - Standardized IVHM services are more attractive / valuable to operators with more than 1 type of equipment.
  - Compliant web-services can be offered that do not expose critical IP of integrator.
Benefits to Fleet Operators

• HRCS helps operators utilize design data to integrate web services into fleet operation and maintenance planning/execution systems.

• Allows operators to implement common IVHM functionality and content across all equipment.
  • Provides users with single process, look and feel for all functions across all types of equipment:
    • Tractors
    • Trailers
    • Major Subsystems
      • HVAC, Engine, Transmission, Brakes, After Treatment, Infotainment, etc.
    • Telematic Systems

• Standard interfaces to compliant web-services simplifies the integration of IVHM functions and content into operator applications.
JA6268 / HRCS Status and Plans

• JA6268 was published by SAE in April 2018.
  • Industry has been highly supportive of JA6268 objectives and methodology.
  • Industry recognizes that JA6268 does not provide all details needed to implement the method.

• HRCS Consortium was established in December 2019 to assist in deployment in JA6268.
  • Members of consortium are working together to specify additional details of data submittals and run-time interfaces.

• Proposals for several pilot programs are being evaluated to exercise all aspects of the practice.
  • Ideal pilot program will include Supplier, Vehicle OEM and Fleet Operators.
  • Commercial Trucking would be a very attractive candidate for pilot.
  • Intent is that pilot program would be substantially completed with 1 year of agreement to proceed.
Commercial Trucking – Proposed Pilot Program

Pilot will demonstrate how JA6268 and HRCS support the integration of IVHM Data and Functionality between Participants.
HEALTH-READY COMPONENTS & SYSTEMS CONSORTIUM

Consortia Background
• HRCS fosters improvements in performance, reliability, and safety
• Required and enabling technology for Autonomous Vehicles/Platooning
• Multi-sector, high overlap with Automotive, Commercial Vehicles, Aerospace, and other mobility sectors

Positioning – Voting membership shapes the program – shapes industry
• OEMS – higher reliability, customer satisfaction, & safety; reduced warranty costs, standardized protocols
• Fleet Operators – moving away from diagnosis and repair to predictive analytics, reduced downtime, standardized protocols and interoperability between tractor and trailer
• Part Suppliers – obtain performance data feedback, standardized protocols, and visibility to customers

Why now? Technologically feasible, drive use of standards before market fragments
WHY JOIN THESE EFFORTS IN THE HRCS CONSORTIUM?

Ensure *interoperability* instead of proprietary solutions

Network with other experts with the protection of operating in a legal, *pre-competitive* environment

Have a voice in IVHM/HRCS development, set *direction and priorities*

*Subcommittees* agree on specific document interchange content and format descriptions building on existing documents (like GM’s ICD component description file and ARINC standards) that can be augmented to better support for health-ready components

*Subcommittees* tackle terminology/lexicon/vocabulary in important industry domains
Questions?