JA6268 CERTIFICATION OF A HEALTH-READY COMPONENT

- Review the scope & goals of SAE JA6268 document
  - ✓ Availability of SOH parameters during operation
  - ✓ Completeness of design information (parameter definitions, engineering units, conversion, models & relationships for proper interpretation)
  - ✓ Assessment of machine-readability of above info (to eliminate source of translation errors)
- Review the status of proposed SAE-ITC Consortium
- Review the status of proposed Health-Ready Components Registry
- Next Steps to Certify JA6268 compliance
  - ✓ Action items to complete
  - ✓ Time line

Supplier Role Crucial for Cost-effective VHM

SURFACE VEHICLE/AEROSPACE RECOMMENDED PRACTICE	JA6268™	APR2018
	Issued	2018-04

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/

SCOPE

This Surface Vehicle & Aerospace Recommended Practice offers best practices and a methodology by which IVHM functionality relating to components and subsystems should be integrated into vehicle or platform level applications. The intent of the document is to provide practitioners with a structured methodology for specifying, characterizing and exposing the inherent IVHM functionality of a component or subsystem using a common functional reference model, i.e., through the exchange of design-time data and the application of standard vehicle data communications interfaces. This document includes best practices and guidance related to the specification of the information that must be exchanged between the functional layers in the IVHM system or between lower-level components/subsystems and the higher-level control system to enable health monitoring and tracking of system degradation severity. The intent is to provide an IVHM system that can robustly report the degradation of a given component before it reaches the point where it goes outside its operational performance envelope by providing sufficient advance notice to deal with the issue. This document does not specify or address how each layer in the IVHM system produces or uses the data available for exchange.

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
- Alternatively, those where the supplier provides the integrator sufficient information to accurately assess the component’s health via a higher-level system on the vehicle
- Information sharing should be machine-readable or math-based
- *This is key to unlocking the potential of VHM!*

Unlocking the Potential of VHM Technology

Positive Feedback from Key Industry Leaders:

Aerospace

"Health-Ready Components on the 787 are enhancing Fleet performance and enabling customer support efficiencies today. This initiative has great potential." -Keith Sellers, 787 Fleet Chief, Boeing

"We really need better mechanisms like JA6268 to engage our supply base to bring IVHM into the mainstream" - Frank Kramer, Technical Specialist, Airbus

"We believe having this standard will accelerate the implementation of Health Monitoring for the civil aviation industry. This platform helps to decrease the costs for all involved and is a must-have for vendors when they move forward with widespread implementation." David Piotrowski – Sr. Principal Engineer – Delta TechOps

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Automotive

"We believe that the most effective path to full implementation of IVHM/PHM technology must include robust best practices for exchanging design and performance information with our supplier partners" - Barbara Leising, Director of Global Aftersales Diagnostics & Electrical Engineering, General Motors

"As a supplier of automotive electronics, I believe that IVHM technology will be critical to the ultimate success of autonomous vehicles and we look forward to further collaboration with the OEMs to advance that goal." -Andre Kleyner, Global Reliability Engineering Leader, APTIV

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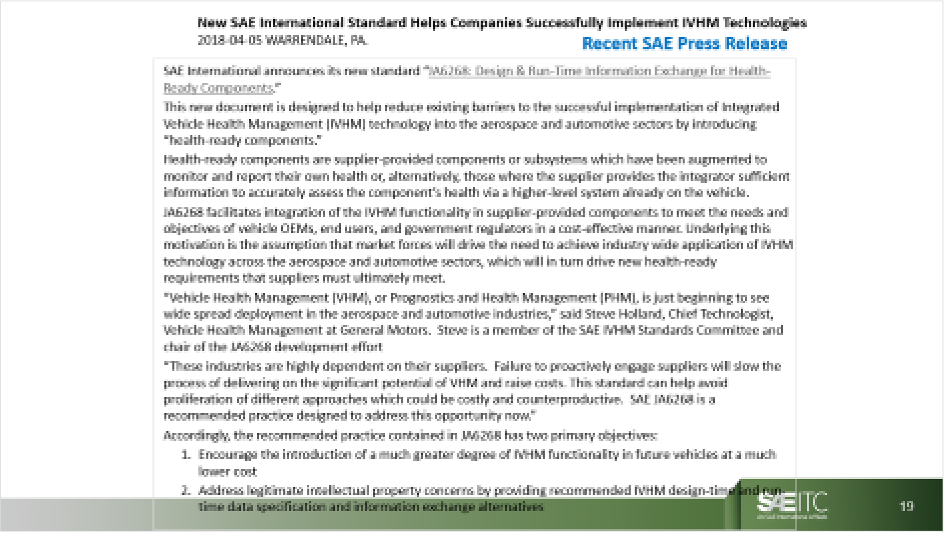
SAE Considers JA6268 a Potential Game Changer

1. SAE Issues Press Release



New SAE International Standard Helps Companies Successfully Implement IVHM Technologies
2018-04-05 WARRENDALE, PA.

Recent SAE Press Release

SAE International announces its new standard "JA6268: Design & Run-Time Information Exchange for Health-Ready Components."

This new 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."

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.

JA6268 facilitates integration of the IVHM functionality in supplier-provided components to meet the needs and objectives of vehicle OEMs, 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 industry wide application of IVHM technology across the aerospace and automotive sectors, which will in turn drive new health-ready requirements that suppliers must ultimately meet.

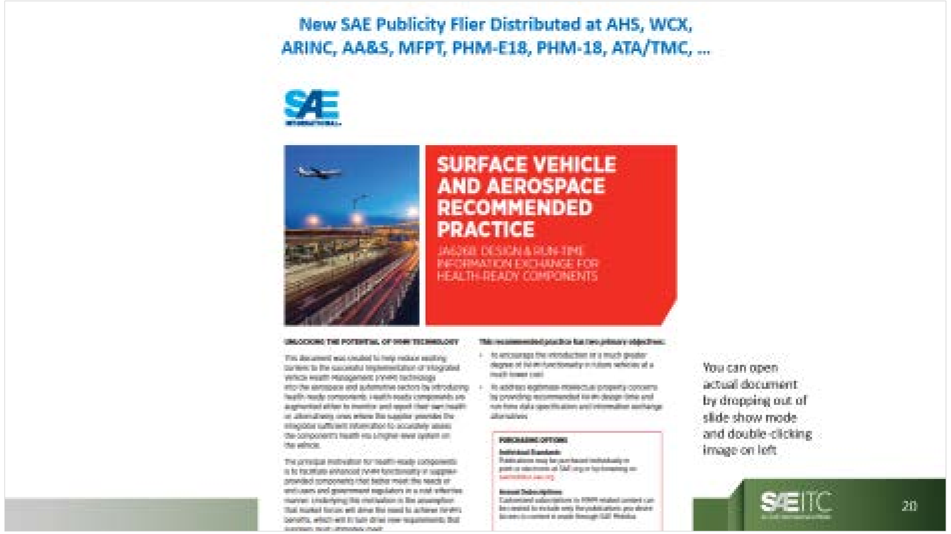
"Vehicle Health Management (VHM), or Prognostics and Health Management (PHM), is just beginning to see wide spread deployment in the aerospace and automotive industries," said Steve Holland, Chief Technologist, Vehicle Health Management at General Motors. Steve is a member of the SAE IVHM Standards Committee and chair of the JA6268 development effort.

"These industries are highly dependent on their suppliers. Failure to proactively engage suppliers will slow the process of delivering on the significant potential of VHM and raise costs. This standard can help avoid proliferation of different approaches which could be costly and counterproductive. SAE JA6268 is a recommended practice designed to address this opportunity now."

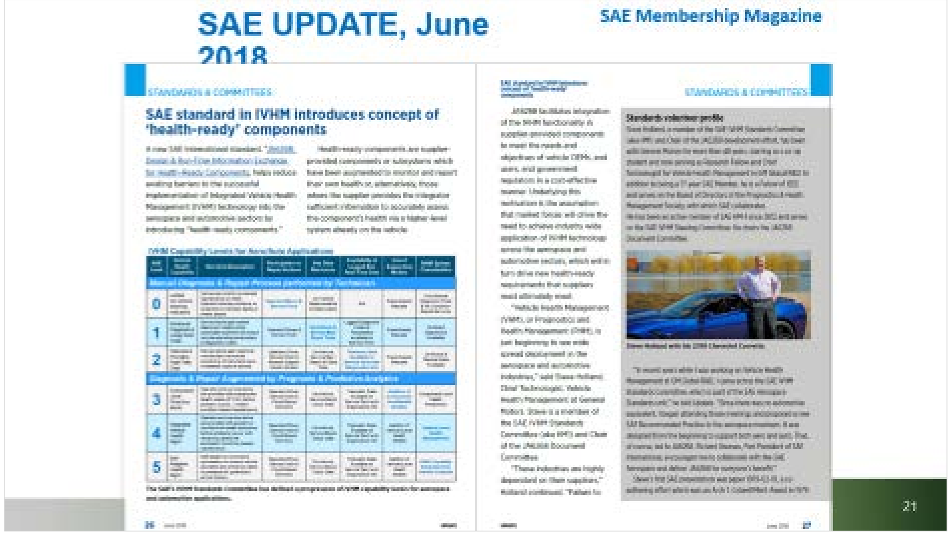
Accordingly, the recommended practice contained in JA6268 has two primary objectives:

1. Encourage the introduction of a much greater degree of IVHM functionality in future vehicles at a much lower cost
2. Address legitimate intellectual property concerns by providing recommended IVHM design-time and run-time data specification and information exchange alternatives

2. SAE Prepares Flier & Publicity Campaign



3. SAE Publishes Story on JA6268



4. SAE Proposes New Consortium

Why is JA6268 important to Industry?

- Motivation is to facilitate & speed the integration of the IVHM functionality for supplier-provided components to meet the needs of
  - OEMs,
  - end users/fleets and
  - government regulators

- Market forces will ultimately drive industry-wide application of IVHM and new health-ready requirements that suppliers must ultimately meet

Why is industry awareness important?

- IVHM has the potential to enable significant business benefits in terms of ***performance, availability and safety***.
- Deployment in aerospace & automotive has been limited.
- One of the key barriers is the lack of uniform information sharing methods.
- There is a window of opportunity to move proactively to accelerate IVHM implementations and avoid unnecessary proliferation of approaches which could be costly and counterproductive.
- SAE HM-1 is establishing a consortium of OEMs & suppliers to positively impact IVHM industry practices—Health-Ready Components & Systems Steering Group (HRCS SG).

Benefits of Health-Ready Components

1. Win-Win-Win Strategic Goal
   - For Suppliers, OEMs & the ***Customer***
2. Supports Emerging Paradigm Shift from Diagnosis to Prognosis
3. Provides for Better Logical Abstractions of Physical Systems
4. Facilitates Sharing of Semantic Data from Suppliers
5. Offers Enhanced Methods for Model-Based Engineering

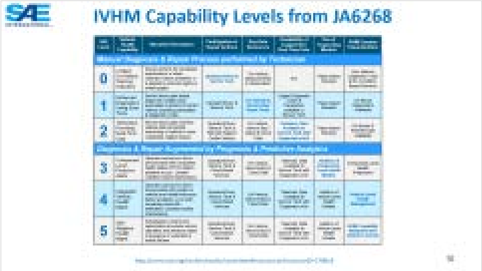
IVHM Capability Levels from JA6268

SAE Level	Vehicle Health Capability	Narrative Description	Participation in Repair Actions	Key Data Resources	Availability of Logged &/or Real-Time Data	Use of Supporting Models	IVHM System Characteristics
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.	**Operator/Driver & Service Tech**	On-Vehicle Measurements & Observation	N/A	Paper-based Manuals	Only Manual Diagnostic Tools & No Condition-Based Services
1	Enhanced Diagnostics Using Scan Tools	Service techs gain added diagnostic insight using automated scanners to extract vehicle operating parameters & diagnostic codes.	Operator/Driver & Service Tech	**On-Vehicle & Service Bay/ Depot Tools**	Logged Diagnostic Codes & Parameters available to Service Tech	Paper-based Manuals	On-Board Diagnostics Available
2	Telematics Providing Real-Time Data	Service techs gain real-time vehicle data via remote monitoring of vehicle to more completely capture issues.	Operator/Driver, Service Tech & Remote Support Center Advisor	On-Vehicle, Service Bay / Depot & Cloud Data	**Telematic Data Available to Service Tech with Diagnostics Info**	Paper-based Manuals	On-Board & Remote Data Available
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.	Operator/Driver, Service Tech & Cloud-Based Services	On-Vehicle, Service Bay & Cloud Data	Telematic Data Available to Service Tech with Diagnostics Info	**Addition of Component-Level Health Models**	Component-Level Health Predictions
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 maintenance.	Operator/Driver, Service Tech & Cloud-Based Services	On-Vehicle, Service Bay & Cloud Data	Telematic Data Available to Service Tech with Diagnostics Info	Addition of Vehicle-Level Health Models	**Vehicle-Level Health Management**
5	Self-Adaptive Health Mgmt.	Self-adaptive control and optimization to extend vehicle operation and enhance safety in presence of potential or actual failures.	Operator/Driver, Service Tech & Cloud-Based Services	On-Vehicle, Service Bay & Cloud Data	Telematic Data Available to Service Tech with Diagnostics Info	Addition of Vehicle-Level Health Models	**IVHM Capability Integrated into Vehicle Controls**

http://www.sae.org/servlets/works/committeeResources.do?resourceID=570618

Evolution of VHM Capability Levels

from a "GM Perspective"


IVHM Capability Levels from JA6268

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

http://www.sae.org/servlets/works/committeeResources.do?resourceID=570618

ADDED EXPLANATION

Because Vehicle Health Management (VHM) system capabilities vary from product to product, SAE International's recommended practice, JA62681, defines six levels of health management capability (identified as level 0 to 5) for aerospace and automotive OEMs, their suppliers, and government regulators to describe a vehicle's health management sophistication. An important paradigm shift occurs between Levels 2 and 3, where vehicle diagnosis and repair processes are augmented with prognosis and predictive analytics. The commonly used progression to characterize analytics ranges from (a) descriptive (that is, classification only) to (b) predictive (that is, ability to forecast or predict coming events) to (c) prescriptive (that is, both the forecast of coming events and actionable advice on how to address it). This also aligns with moving up the hierarchy from input data alone transformed into useful information, and then to knowledge, and ultimately to a prescribed action. See next slide.

Level 0: Limited On-Vehicle Warning Indicators

Vehicle maintenance actions are prompted by either scheduled maintenance intervals or when the vehicle operator is alerted by indicator lights, simple gauges or observes a performance issue.

Level 1: Enhanced Diagnostics using Portable Maintenance Aids

Vehicle is equipped with on-vehicle diagnostic software (e.g., OBD, BIT, HUMS). Maintenance technician gains added diagnostic insight using portable maintenance aids or scan tools to extract vehicle operating parameters and/or diagnostic codes (e.g., DTC, BIT, CI, or HRC) that were calculated and retained on-board specifically to enhance the diagnostic process.

Level 2: Remote Health Monitoring

Vehicle is equipped with data link to transmit diagnostic health indicators and operating parameters to maintenance technicians or to a central support center. Maintenance technician gains added diagnostic insight (in advance) without having to physically be there. In addition, the data can be used to monitor real-time performance or to capture performance history over time for subsequent analysis

Level 3: Component Level Proactive Alerts

Vehicle operator and maintenance technician are provided with component Proactive Alert Identifiers (PAI) as alerts of impending problems, possibly listing severity (Red/Yellow/Green), along with estimated component Performance Life Remaining (PLR) or Remaining Useful Life (RUL) and recommended remediation actions.

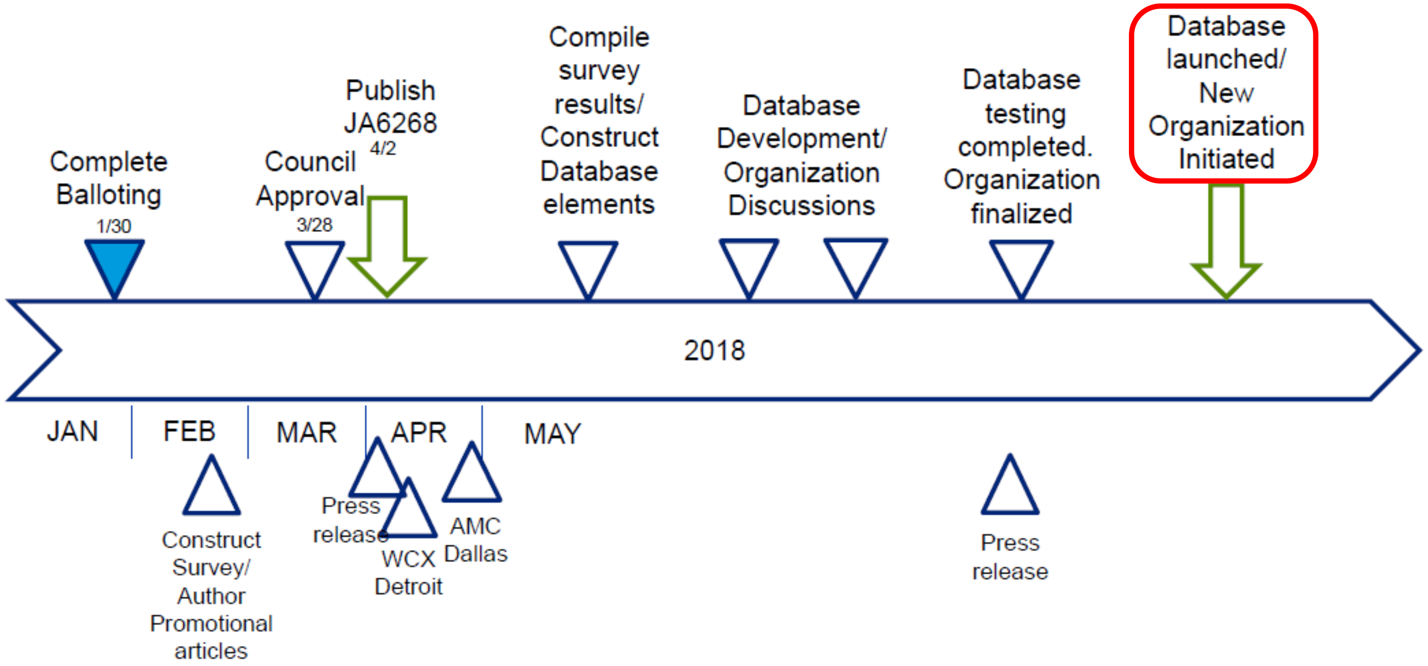
Level 4: Vehicle Level Health Management

Operator and maintenance technician are provided with cross-system or vehicle-level health indictors before problems occur, along with estimated critical function Performance Life Remaining (PLR) or Remaining Useful Life (RUL) and recommended remediation actions.

Level 5: Self-adaptive Health Management

VHM capability is integrated with vehicle control functions to provide autonomous, real-time, self-adaptive control and optimization to extend vehicle operation and enhance mission completion and/or safety, in the presence of component or system degradation.

SAE-ITC Health-Ready Components Consortia Planning



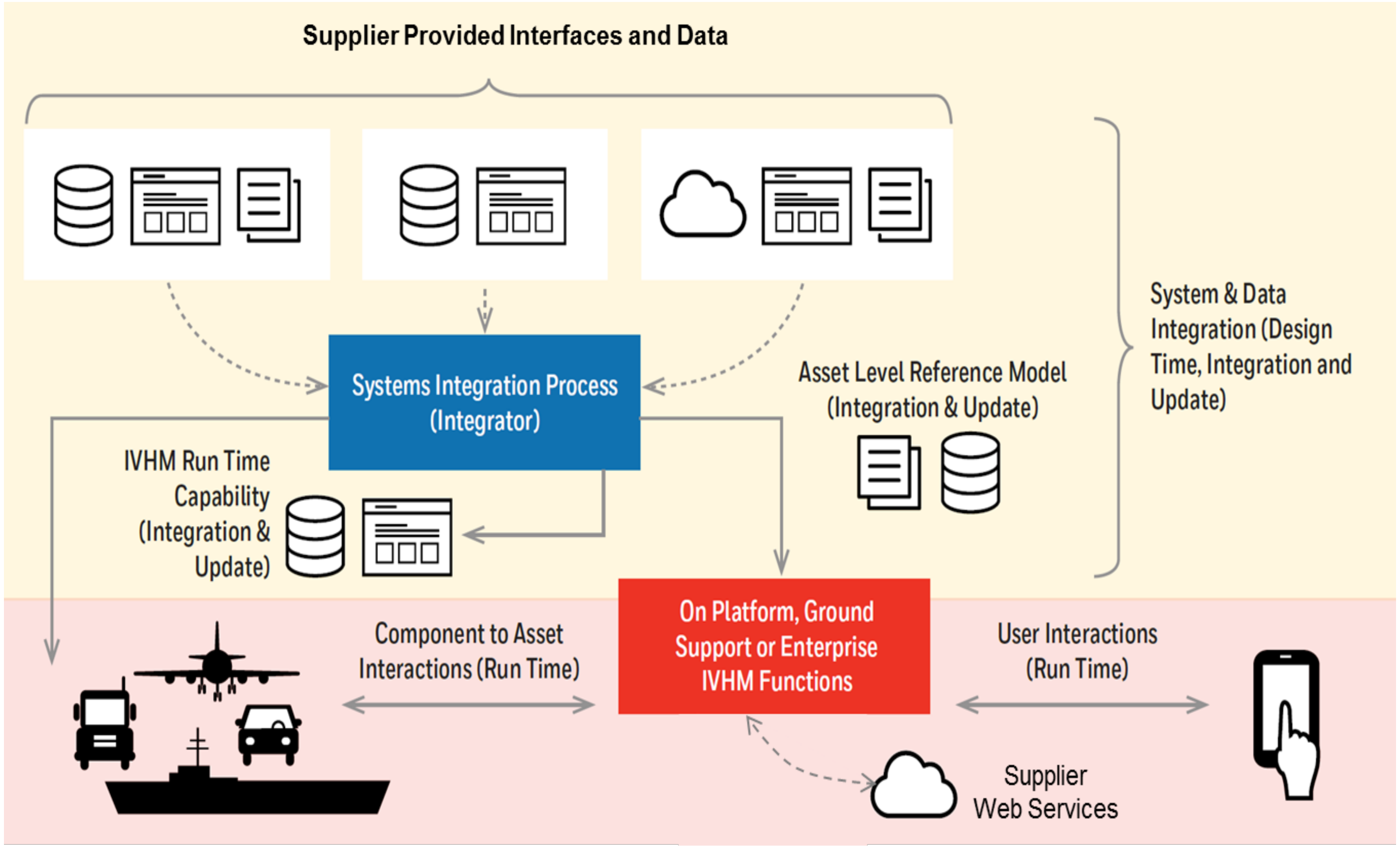
SAE JA6268 Press Release:
https://www.sae.org/news/press-room/2018/03/new-sae-international-standard-helps-companies-successfully-implement-ivhm-technologies
SAE-ITC HRC Website:
https://www.sae-itc.com/case-study/unlocking-potential-ivhm-technology
SAE-ITC HRC Survey:
https://sae.qualtrics.com/jfe/form/SV_4UVSLGrMyO4BDYF

What information would be put in Registry?

- The name of the component (and known aliases)
- The Suppliers catalog reference number (or numbers)
- The Suppliers contact information and DUNS number, CAGE Code or other industry standard supplier identifier (if applicable)
- An explanation of whether the validation is based upon (a) design-time information, (b) run time information or (c) both design-time and run-time information and how it is handled from a high-level point of view
- A key aspect of Health Ready information is it provides a mathematical model (or mathematical relationships) in a machine-readable format to allow for a proper interpretation and use of specific component parameters
- The name of the Integrator or OEM providing the validation along with their contact information and DUNS number (if applicable)
- The date upon which the validation was completed and the date at which the validation expires (if applicable)

\+ Other items to be determined by HRCS SG (all non-proprietary)

Design Time or Run Time?



SAE INTERNATIONAL

What functionality?

Real-time IVHM Functions & Processes	Non-Real-time IVHM Functions & Processes
• Analog I/O and digitization • Serial I/O and parameter extraction • Signal processing, filtering and state detection • Fault detection and reporting • Support for Initiated Test functionality and protocols • Performance or degradation reporting • Intermittent fault data capture • Functional availability reporting • On-platform screen and user message generation • Usage monitoring and reporting of usage related data • System mode or state reporting • System configuration reporting • Data recording/logging management	• Feature Extraction • Diagnostics & Fault isolation: - Nuisance suppression (events which can safely be ignored) - Cascade removal (additional symptoms triggered by one symptom that don't add diagnostic value) - Correlation of loss of function to root cause - Guided troubleshooting and repair • Prognostics • Maintenance planning • Logistics or material planning • Supplemental analytics • Anomaly Detection • Engineering Analysis: - Root Cause Analysis - Precursor Analysis - Fleet Performance Analysis - Design Improvement Analysis • Bench Testing

Math-Based Models

Typical approach in current aerospace pgms

Typical approach in current automotive pgms

Interface Message Syntax	Internal Symantic Model: Not Supplied	Internal Symantic Model: Manual Format	Internal Symantic Model: Automated Format
Not Supplied	Not Health Ready	Not Health Ready	Not Health Ready
Manual Format	Not Health Ready	Not Health Ready	Not Health Ready
Automated Format	Health Ready *	Health Ready *	Health Ready

* Provided that the supplier implements all required IVHM functionality inside their boundary