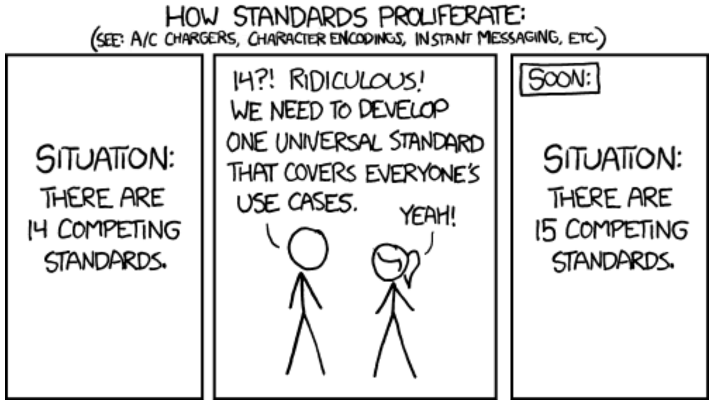
# PHME Standards Panel

## What you need to know and how they can help you



xkcd, 2013

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

**Provocative remarks by panelists**

- Rhonda Walthall, Collins Aerospace
- Tim Felke, Garrett Motion
- Brian Weiss, National Institute of Standards and Technology

**Open discussion through Zoom and Sli.do**

**Moderator: Karl Reichard, Penn State**

Intro: How is the PHM Society trying to integrate access and contributions?

1. **What new existing and new standards are coming from the main standards developing organizations?**
2. **How to contribute and identify gaps?**
3. **How could the PHM Society help?**

Desired Outcomes

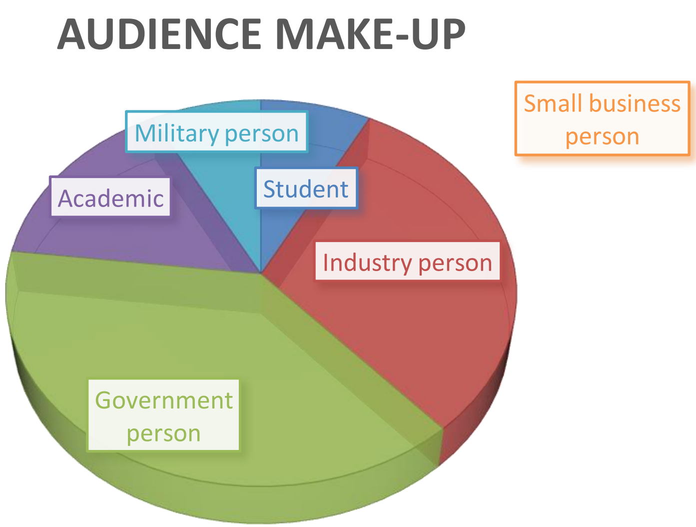
> Summary of access methods: PHM Society website & standards page; dedicated sites

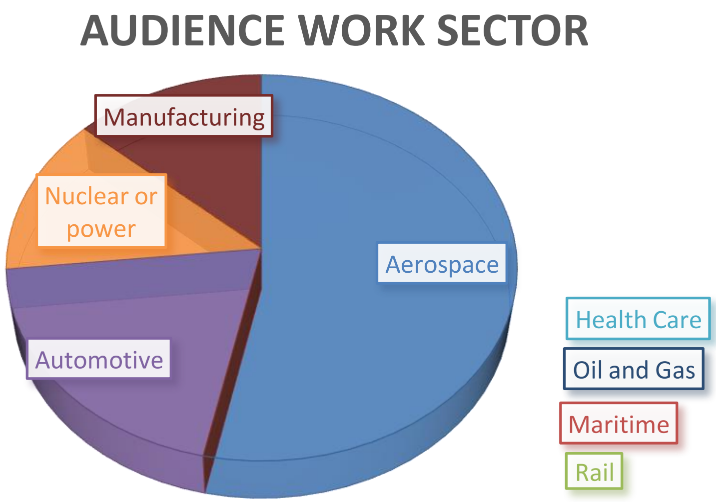
> Priorities on gaps in knowledge & processes

**PHM Society Standards Committee**

Brian Weiss, Jeff Bird, John Madsen, Ravi Rajamani

# Audience Demographics Slido Poll



# 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

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4. To mature knowledge from theory to practice is challenging: Knowing about relevant standards 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

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# PHM Society Activities

**Traditional**

1. Panels
2. Special issues of journal and tutorials- subjects?
3. Program updates and on-line forum
4. Connections among current PHMers

**New initiatives**

1. Standards Users Group
2. PHM Standards Portal: One stop for docs, resources, forum
3. Interactions with SAE, ASME, IEEE, ISA, NIST
4. Standards Review Portal: *PHM- ISO Connect*
5. *Domain specific like Machine Learning ??*

Join SLIDO Q&A chat & Poll window on the right of the Code # PanelSession1 PRIORITIES Ranking

# PHM Standards Panelists

Aerospace: Rhonda Walthall, Collins Aerospace

Automotive: Tim Felke, Garrett Motion

Manufacturing: Brian Weiss, National Institute of Standards and Technology

Questions to be addressed:

1. What new existing and new standards are coming from the main standards developing organizations?
2. How to contribute and identify gaps?
3. How could the PHM Society help?

# Audience Priorities Slido Poll

# Standards for PHM in Aerospace

Rhonda Walthall
November 30, 2021
rhonda.walthall@collins.com

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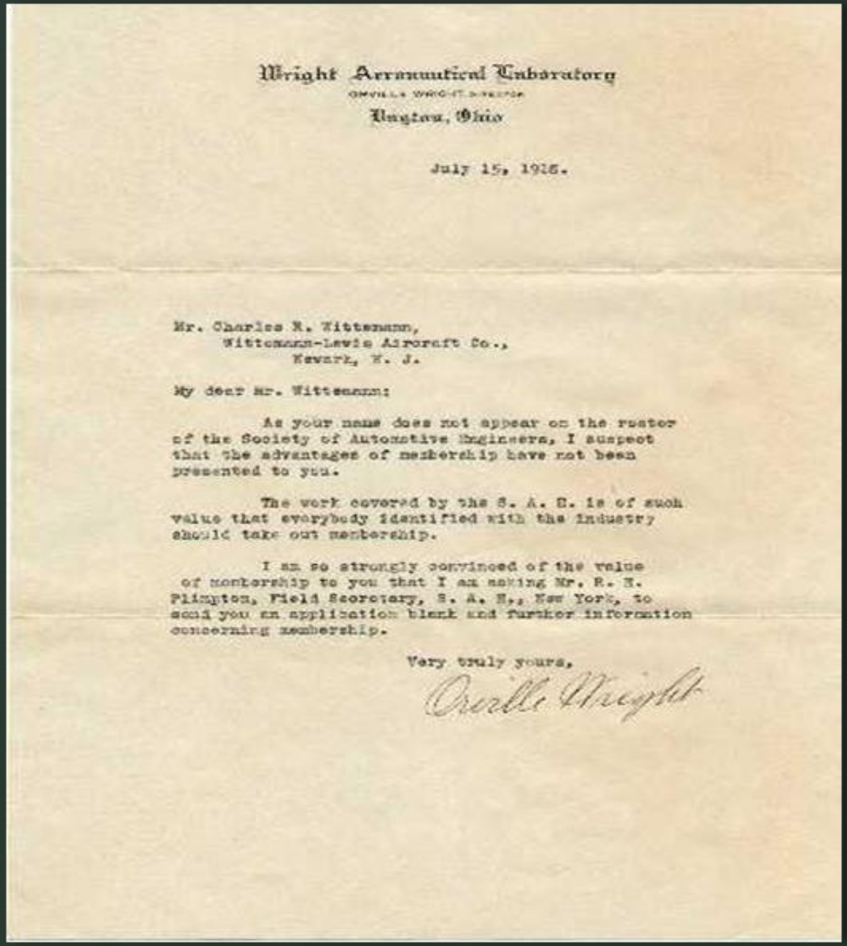
SAE INTERNATIONAL

Collins Aerospace

# SAE AEROSPACE STANDARDS



Wright Aeronautical Laboratory
ORVILLE WRIGHT DIRECTOR
Dayton, Ohio

July 15, 1918.

Mr. Charles R. Wittemann,
Wittemann-Lewis Aircraft Co.,
Newark, N. J.

My dear Mr. Wittemann:

As your name does not appear on the roster of the Society of Automotive Engineers, I suspect that the advantages of membership have not been presented to you.

The work covered by the S. A. E. is of such value that everybody identified with the industry should take out membership.

I am so strongly convinced of the value of membership to you that I am asking Mr. R. E. Plimpton, Field Secretary, S. A. E., New York, to send you an application blank and further information concerning membership.

Very truly yours,

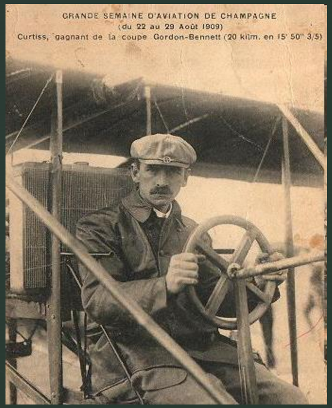
Orville Wright

The Wright Brothers

"The work covered by the SAE is of such value that everybody identified with the industry should take out membership."
Orville Wright, 1918

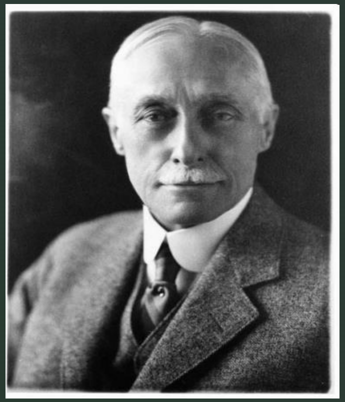
# SAE MEMBERS: AVIATION PIONEERS


Orville Wright



Glenn Curtiss


Glenn Martin


Elmer Sperry


Chance Vought

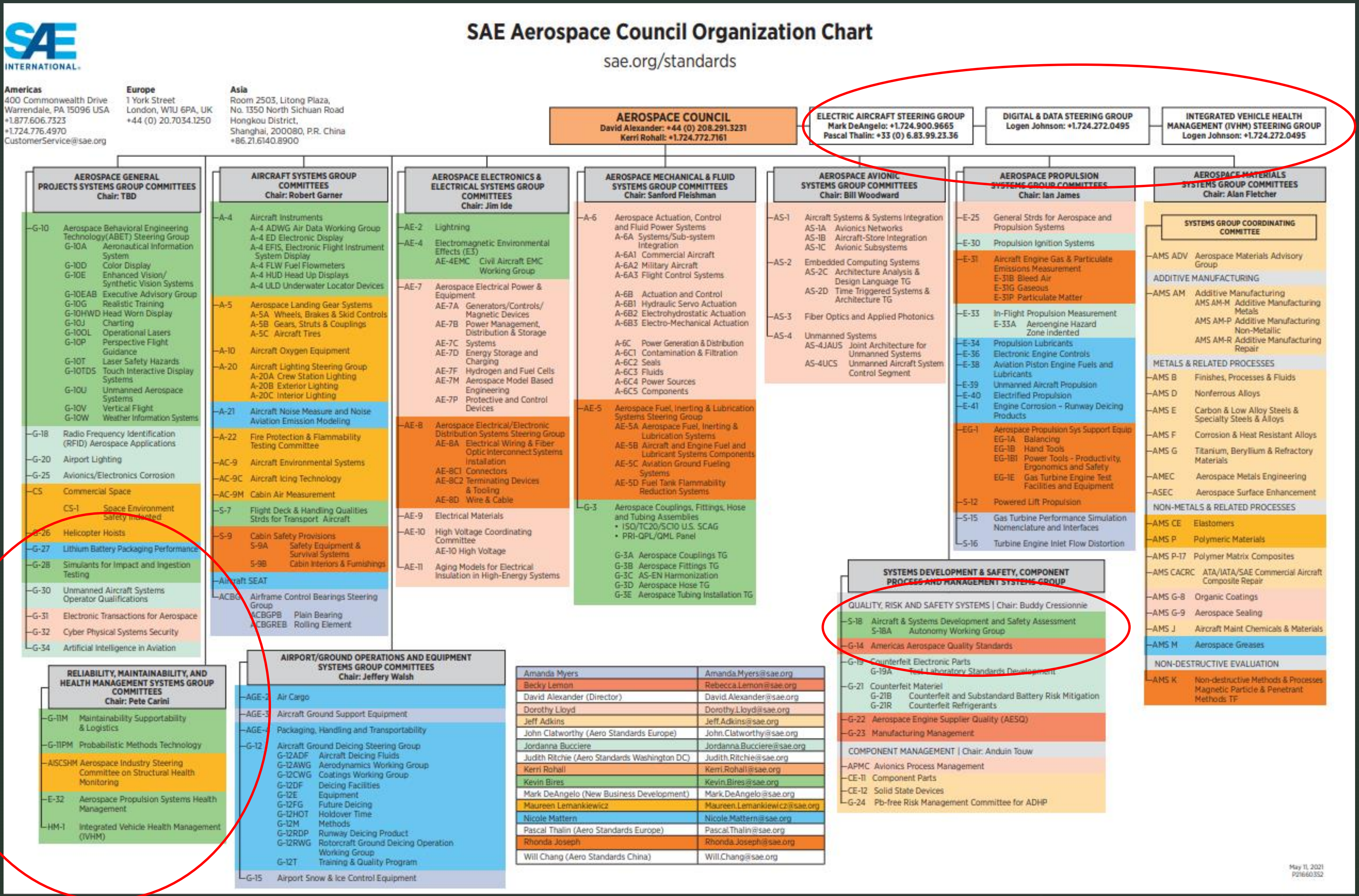

Jimmy Doolittle


Charles Lindbergh


Amelia Earhart


Kelly Johnson


Igor Sikorsky


SAE Aerospace Council Organization Chart
sae.org/standards
SAE INTERNATIONAL
Americas
400 Commonwealth Drive
Warrendale, PA 15096 USA
+1.877.606.7323
+1.724.776.4970
CustomerService@sae.org
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+44 (0) 20.7034.1250
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+86.21.6140.8900
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INTEGRATED VEHICLE HEALTH MANAGEMENT (IVHM) STEERING GROUP
Logen Johnson: +1.724.272.0495
AEROSPACE GENERAL PROJECTS SYSTEMS GROUP COMMITTEES
Chair: TBD
G-10 Aerospace Behavioral Engineering Technology(ABET) Steering Group
G-10A Aeronautical Information System
G-10D Color Display
G-10E Enhanced Vision/Synthetic Vision Systems
G-10EAB Executive Advisory Group
G-10G Realistic Training
G-10HWD Head Worn Display
G-10J Charting
G-10OL Operational Lasers
G-10P Perspective Flight Guidance
G-10T Laser Safety Hazards
G-10TDS Touch Interactive Display Systems
G-10U Unmanned Aerospace Systems
G-10V Vertical Flight
G-10W Weather Information Systems
G-18 Radio Frequency Identification (RFID) Aerospace Applications
G-20 Airport Lighting
G-25 Avionics/Electronics Corrosion
CS Commercial Space
CS-1 Space Environment Safety Integrated
G-26 Helicopter Hoists
G-27 Lithium Battery Packaging Performance
G-28 Simulants for Impact and Ingestion Testing
G-30 Unmanned Aircraft Systems Operator Qualifications
G-31 Electronic Transactions for Aerospace
G-32 Cyber Physical Systems Security
G-34 Artificial Intelligence in Aviation
AIRCRAFT SYSTEMS GROUP COMMITTEES
Chair: Robert Garner
A-4 Aircraft Instruments
A-4 ADWG Air Data Working Group
A-4 ED Electronic Display
A-4 EFIS, Electronic Flight Instrument System Display
A-4 FLW Fuel Flowmeters
A-4 HUD Head Up Displays
A-4 ULD Underwater Locator Devices
A-5 Aerospace Landing Gear Systems
A-5A Wheels, Brakes & Skid Controls
A-5B Gears, Struts & Couplings
A-5C Aircraft Tires
A-10 Aircraft Oxygen Equipment
A-20 Aircraft Lighting Steering Group
A-20A Crew Station Lighting
A-20B Exterior Lighting
A-20C Interior Lighting
A-21 Aircraft Noise Measure and Noise Aviation Emission Modeling
A-22 Fire Protection & Flammability Testing Committee
AC-9 Aircraft Environmental Systems
AC-9C Aircraft Icing Technology
AC-9M Cabin Air Measurement
S-7 Flight Deck & Handling Qualities Strds for Transport Aircraft
S-9 Cabin Safety Provisions
S-9A Safety Equipment & Survival Systems
S-9B Cabin Interiors & Furnishings
Aircraft SEAT
ACBG Airframe Control Bearings Steering Group
ACBGPB Plain Bearing
ACBGREB Rolling Element
AEROSPACE ELECTRONICS & ELECTRICAL SYSTEMS GROUP COMMITTEES
Chair: Jim Ide
AE-2 Lightning
AE-4 Electromagnetic Environmental Effects (E3)
AE-4EMC Civil Aircraft EMC Working Group
AE-7 Aerospace Electrical Power & Equipment
AE-7A Generators/Controls/Magnetic Devices
AE-7B Power Management, Distribution & Storage
AE-7C Systems
AE-7D Energy Storage and Charging
AE-7F Hydrogen and Fuel Cells
AE-7M Aerospace Model Based Engineering
AE-7P Protective and Control Devices
AE-8 Aerospace Electrical/Electronic Distribution Systems Steering Group
AE-8A Electrical Wiring & Fiber Optic Interconnect Systems Installation
AE-8C1 Connectors
AE-8C2 Terminating Devices & Tooling
AE-8D Wire & Cable
AE-9 Electrical Materials
AE-10 High Voltage Coordinating Committee
AE-10 High Voltage
AE-11 Aging Models for Electrical Insulation in High-Energy Systems
AEROSPACE MECHANICAL & FLUID SYSTEMS GROUP COMMITTEES
Chair: Sanford Fleishman
A-6 Aerospace Actuation, Control and Fluid Power Systems
A-6A Systems/Sub-system Integration
A-6A1 Commercial Aircraft
A-6A2 Military Aircraft
A-6A3 Flight Control Systems
A-6B Actuation and Control
A-6B1 Hydraulic Servo Actuation
A-6B2 Electrohydrostatic Actuation
A-6B3 Electro-Mechanical Actuation
A-6C Power Generation & Distribution
A-6C1 Contamination & Filtration
A-6C2 Seals
A-6C3 Fluids
A-6C4 Power Sources
A-6C5 Components
AE-5 Aerospace Fuel, Inerting & Lubrication Systems Steering Group
AE-5A Aerospace Fuel, Inerting & Lubrication Systems
AE-5B Aircraft and Engine Fuel and Lubricant Systems Components
AE-5C Aviation Ground Fueling Systems
AE-5D Fuel Tank Flammability Reduction Systems
G-3 Aerospace Couplings, Fittings, Hose and Tubing Assemblies
• ISO/TC20/SC10 U.S. SCAG
• PRI-QPL/QML Panel
G-3A Aerospace Couplings TG
G-3B Aerospace Fittings TG
G-3C AS-EN Harmonization
G-3D Aerospace Hose TG
G-3E Aerospace Tubing Installation TG
AEROSPACE AVIONIC SYSTEMS GROUP COMMITTEES
Chair: Bill Woodward
AS-1 Aircraft Systems & Systems Integration
AS-1A Avionics Networks
AS-1B Aircraft-Store Integration
AS-1C Avionic Subsystems
AS-2 Embedded Computing Systems
AS-2C Architecture Analysis & Design Language TG
AS-2D Time Triggered Systems & Architecture TG
AS-3 Fiber Optics and Applied Photonics
AS-4 Unmanned Systems
AS-4JAUS Joint Architecture for Unmanned Systems
AS-4UCS Unmanned Aircraft System Control Segment
AEROSPACE PROPULSION SYSTEMS GROUP COMMITTEES
Chair: Ian James
E-25 General Strds for Aerospace and Propulsion Systems
E-30 Propulsion Ignition Systems
E-31 Aircraft Engine Gas & Particulate Emissions Measurement
E-31B Bleed Air
E-31G Gaseous
E-31P Particulate Matter
E-33 In-Flight Propulsion Measurement
E-33A Aeroengine Hazard Zone Indented
E-34 Propulsion Lubricants
E-36 Electronic Engine Controls
E-38 Aviation Piston Engine Fuels and Lubricants
E-39 Unmanned Aircraft Propulsion
E-40 Electrified Propulsion
E-41 Engine Corrosion – Runway Deicing Products
EG-1 Aerospace Propulsion Sys Support Equip
EG-1A Balancing
EG-1B Hand Tools
EG-1B1 Power Tools - Productivity, Ergonomics and Safety
EG-1E Gas Turbine Engine Test Facilities and Equipment
S-12 Powered Lift Propulsion
S-15 Gas Turbine Performance Simulation Nomenclature and Interfaces
S-16 Turbine Engine Inlet Flow Distortion
AEROSPACE MATERIALS SYSTEMS GROUP COMMITTEES
Chair: Alan Fletcher
SYSTEMS GROUP COORDINATING COMMITTEE
AMS ADV Aerospace Materials Advisory Group
ADDITIVE MANUFACTURING
AMS AM Additive Manufacturing
AMS AM-M Additive Manufacturing Metals
AMS AM-P Additive Manufacturing Non-Metallic
AMS AM-R Additive Manufacturing Repair
METALS & RELATED PROCESSES
AMS B Finishes, Processes & Fluids
AMS D Nonferrous Alloys
AMS E Carbon & Low Alloy Steels & Specialty Steels & Alloys
AMS F Corrosion & Heat Resistant Alloys
AMS G Titanium, Beryllium & Refractory Materials
AMEC Aerospace Metals Engineering
ASEC Aerospace Surface Enhancement
NON-METALS & RELATED PROCESSES
AMS CE Elastomers
AMS P Polymeric Materials
AMS P-17 Polymer Matrix Composites
AMS CACRC ATA/IATA/SAE Commercial Aircraft Composite Repair
AMS G-8 Organic Coatings
AMS G-9 Aerospace Sealing
AMS J Aircraft Maint Chemicals & Materials
AMS M Aerospace Greases
NON-DESTRUCTIVE EVALUATION
AMS K Non-destructive Methods & Processes Magnetic Particle & Penetrant Methods TF
SYSTEMS DEVELOPMENT & SAFETY, COMPONENT PROCESS AND MANAGEMENT SYSTEMS GROUP
QUALITY, RISK AND SAFETY SYSTEMS | Chair: Buddy Cressionnie
S-18 Aircraft & Systems Development and Safety Assessment
S-18A Autonomy Working Group
G-14 Americas Aerospace Quality Standards
G-19 Counterfeit Electronic Parts
G-19A Test Laboratory Standards Development
G-21 Counterfeit Materiel
G-21B Counterfeit and Substandard Battery Risk Mitigation
G-21R Counterfeit Refrigerants
G-22 Aerospace Engine Supplier Quality (AESQ)
G-23 Manufacturing Management
COMPONENT MANAGEMENT | Chair: Anduin Touw
APMC Avionics Process Management
CE-11 Component Parts
CE-12 Solid State Devices
G-24 Pb-free Risk Management Committee for ADHP
RELIABILITY, MAINTAINABILITY, AND HEALTH MANAGEMENT SYSTEMS GROUP COMMITTEES
Chair: Pete Carini
G-11M Maintainability Supportability & Logistics
G-11PM Probabilistic Methods Technology
AISCSHM Aerospace Industry Steering Committee on Structural Health Monitoring
E-32 Aerospace Propulsion Systems Health Management
HM-1 Integrated Vehicle Health Management (IVHM)
AIRPORT/GROUND OPERATIONS AND EQUIPMENT SYSTEMS GROUP COMMITTEES
Chair: Jeffery Walsh
AGE-2 Air Cargo
AGE-3 Aircraft Ground Support Equipment
AGE-4 Packaging, Handling and Transportability
G-12 Aircraft Ground Deicing Steering Group
G-12ADF Aircraft Deicing Fluids
G-12AWG Aerodynamics Working Group
G-12CWG Coatings Working Group
G-12DF Deicing Facilities
G-12E Equipment
G-12FG Future Deicing
G-12HOT Holdover Time
G-12M Methods
G-12RDP Runway Deicing Product
G-12RWG Rotorcraft Ground Deicing Operation Working Group
G-12T Training & Quality Program
G-15 Airport Snow & Ice Control Equipment
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Becky Lemon Rebecca.Lemon@sae.org
David Alexander (Director) David.Alexander@sae.org
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May 11, 2021
P21660352

# SAE IVHM Steering Group

- Strategically identify emerging technologies and coordinate standardization activities across SAE committees necessary to support IVHM at the top level, system level, and component level

- Maintain an emerging technology brief and roadmap for IVHM
- Maintain a matrix that tracks coordination, alignment, and gaps
- Recommend standards necessary to advance IVHM development

# IVHM Capability Levels

| 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 |

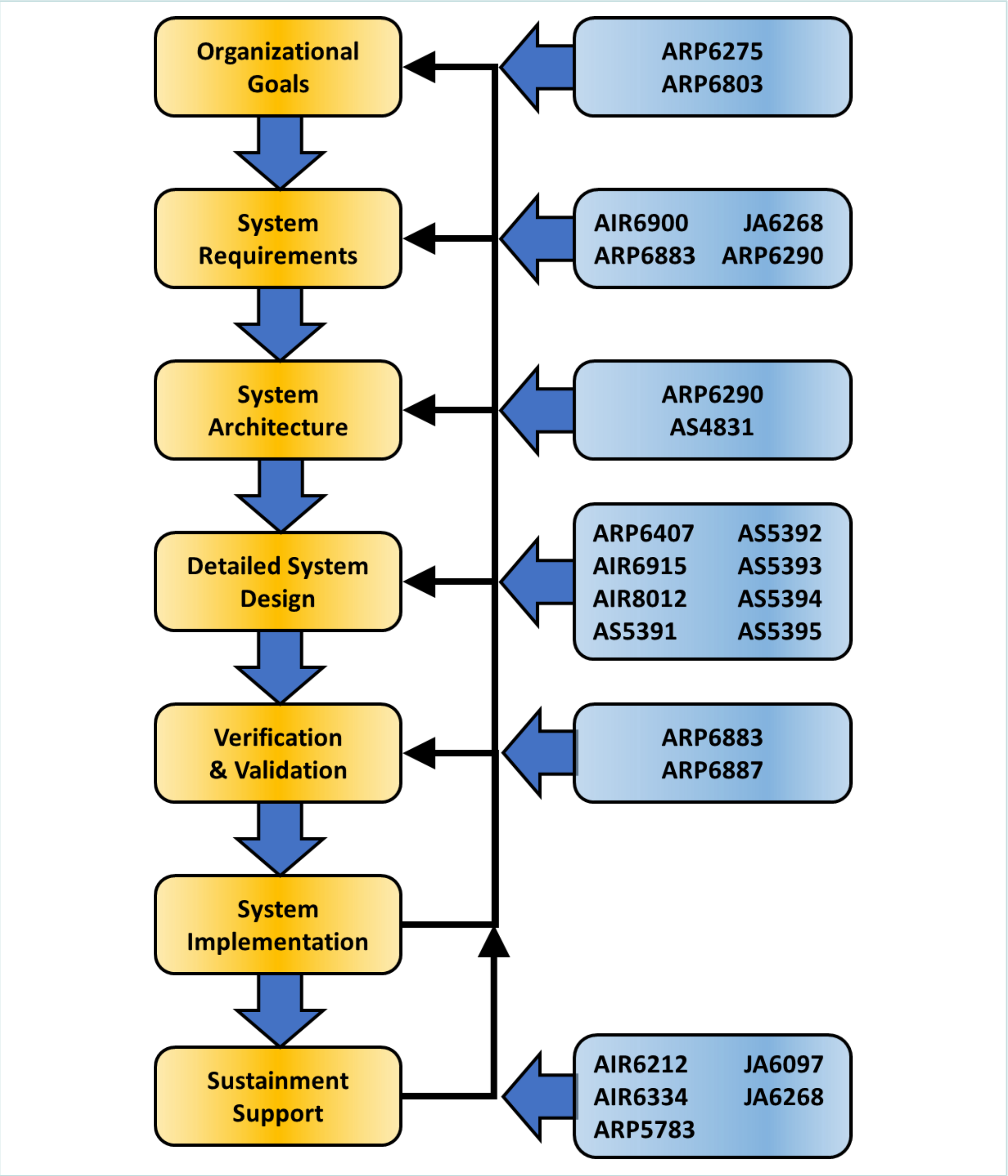
Source: SAE JA6268

# SAE HM-1 Committee

The HM-1 Committee serves as a forum to gather, develop, record and publish expert information in the discipline of IVHM.

- Civil fixed and rotary wing air vehicles
- Military fixed and rotary wing air vehicles
- Unmanned fixed and rotary wing air vehicles
- Data processing equipment, systems and software
- Air vehicle maintenance platforms

Driving changes in 2022 to the MSG-3 Analysis



# SAE HM-1: Integrated Vehicle Health Management Committee

- 5 AIRs + 1 WIP
- 5 ARPs + 3 WIP
- 6 ASs
- 2 JAs + 1 WIP

**Gaps:**
Autonomous Systems
Electric / Hybrid Aircraft
Implementation / Fielded Systems
Specific System / Component Level
PHM in the Active Control
MBSE
Lessons Learned
General Aviation
Space

*Soon to be published:*
- ARP6290 – Guidelines for the Development of Architectures for IVHM Systems

*In WIP:*
- ARP7122 – Utilizing Aircraft Integrated Health Management for Maintenance Credits
- AIR6970 - Atmospheric Corrosion Monitoring
- ARP6887 – V&V of IVHM Systems
- JA1013 – CBM Recommended Practices

*Under Consideration:*
- IVHM for Autonomous Vehicles

Feb 22-24, 2022 – West Palm Beach, FL
Fall 2022 – Lisbon, Portugal

# SAE E-32: Propulsion System Health Management Committee

- 11 AIRs + 6 WIP
- 9 ARPs + 4 WIP

**Gaps:**
Reciprocating Engines
Electric Propulsion
Hybrid Propulsion
Hydrogen Fuel Cell Propulsion

*Soon to be published:*

- AIR4985A – A Methodology for Quantifying the Performance of an Engine Monitoring System

*In WIP:*

- ARP1587C – Aircraft Gas Turbine Engine Health Management System Guide
- ARP5987A – A Process for Utilizing Aerospace Propulsion Health Management for Maintenance Credit
- ARP6835 – Propulsion System Monitoring for Continued Airworthiness

Mar 29-31, 2022 – Madrid, Spain
Fall 2022 – San Diego, CA
Spring 2023 – Long Island, NY – Meeting #100!

# SAE AISCSHM: Aerospace Industrial Steering Committee for Structural Health Monitoring

- 2 AIRs
- 1 ARP + 1 WIP

**Gaps:**
General Aviation
Requirements
Certification
Design
Architecture
V&V

*Published:*

- AIR6245 – Perspectives on Integrating Structural Health Monitoring Systems into Fixed-Wing Military Aircraft
- AIR6892 – Structural Health Monitoring Considerations and Guidance Specific to Rotorcraft
- ARP6461A – Guidelines for Implementation of Structural Health Monitoring on Fixed Wing Aircraft

*In WIP:*

- ARP6821 – Guidance for Assessing the Damage Detection capability of Structural Health Monitoring Systems

SHM Summit with Regulators planned for 2022
Meets in conjunction with IWSHM at Stanford

# Adjacent Aerospace Committees

- DDSG: Digital & Data Steering Group
- G-11M: Maintainability, Supportability and Logistics
- G-11PM: Probabilistic Methods Technology
- G-34: Artificial Intelligence in Aviation
- G-35: Modeling, Simulation, Training for Emerging AV Technologies
- S-18: Aircraft and Systems Development and Safety Assessment
- AS-3: Fiber-Optics and Applied Photonics
- A-6: Aerospace Actuation, Control and Fluid Power Systems
- AE-5: Aerospace Fuel, Oil and Oxidizer Systems Steering Group
- A-5: Aerospace Landing Gear Systems

*Numerous Automotive committees focusing on autonomous, alternative power, and D&PHM*

# How to Get Involved

- Contact SAE Committee Manager, Kevin Bires: kevin.bires@sae.org

Questions for the audience  for the Q&A

1. **What PHM standards would you like to see developed?**

**SLIDO Audience Poll:**

1. **V&V**
2. **System of Systems**
3. **Adopting new PHM tech**
4. **Uncertainty Management**
5. **PHM terms & definitiuons**
6. **PHM Security**
7. **Sub-component Health**
8. **Explainability**
9. **Performance**
10. **Machine Learning**

2. Which standards development organizations do feel produces the most relevant standards and best practices for your area of interest?
3. What is your primary source for PHM standards and recommended practices?

# Using JA6268 to Develop PHM Applications

Tim Felke
Engineering Fellow,
Garrett Advancing Motion
November 30, 2021

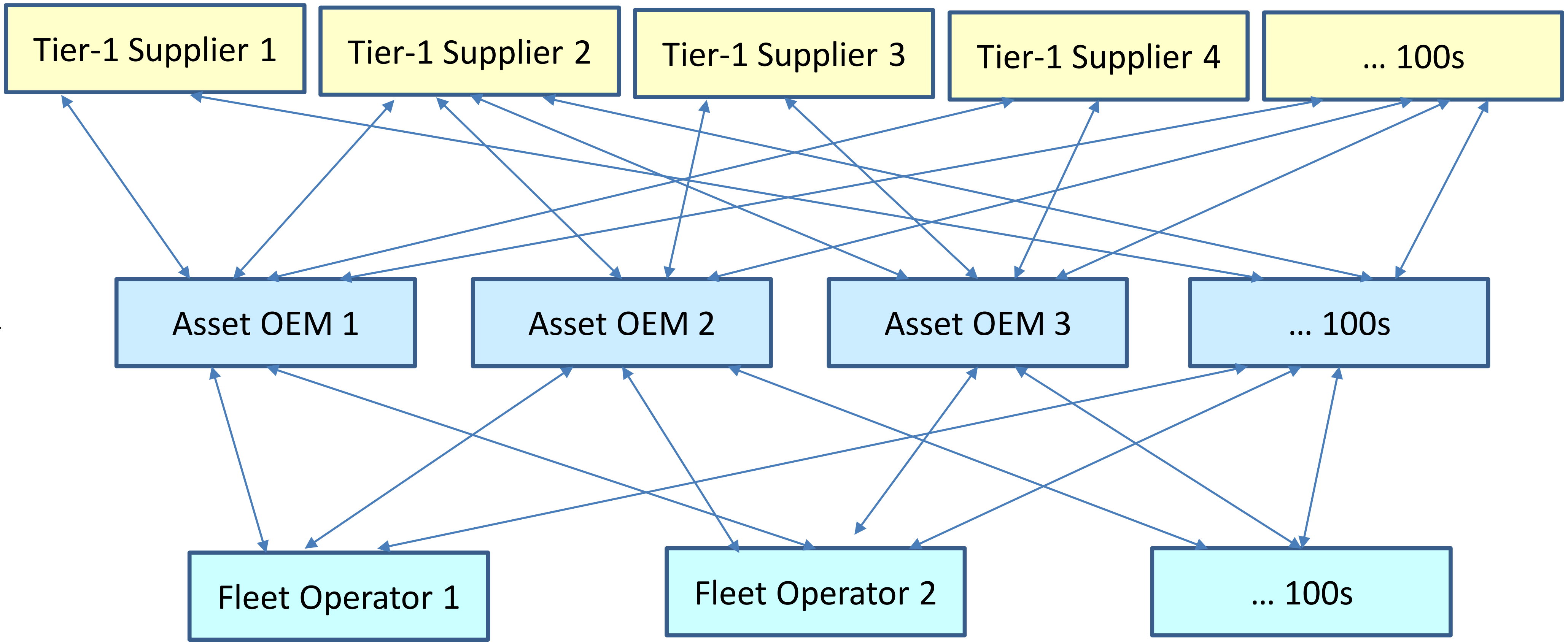
# JA6268 PRIMARY USE CASE

## Interoperability of IVHM functions is hampered by differences between data definitions

*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*



phmsociety

# FOUNDATIONAL DOCUMENT: SAE JA6268



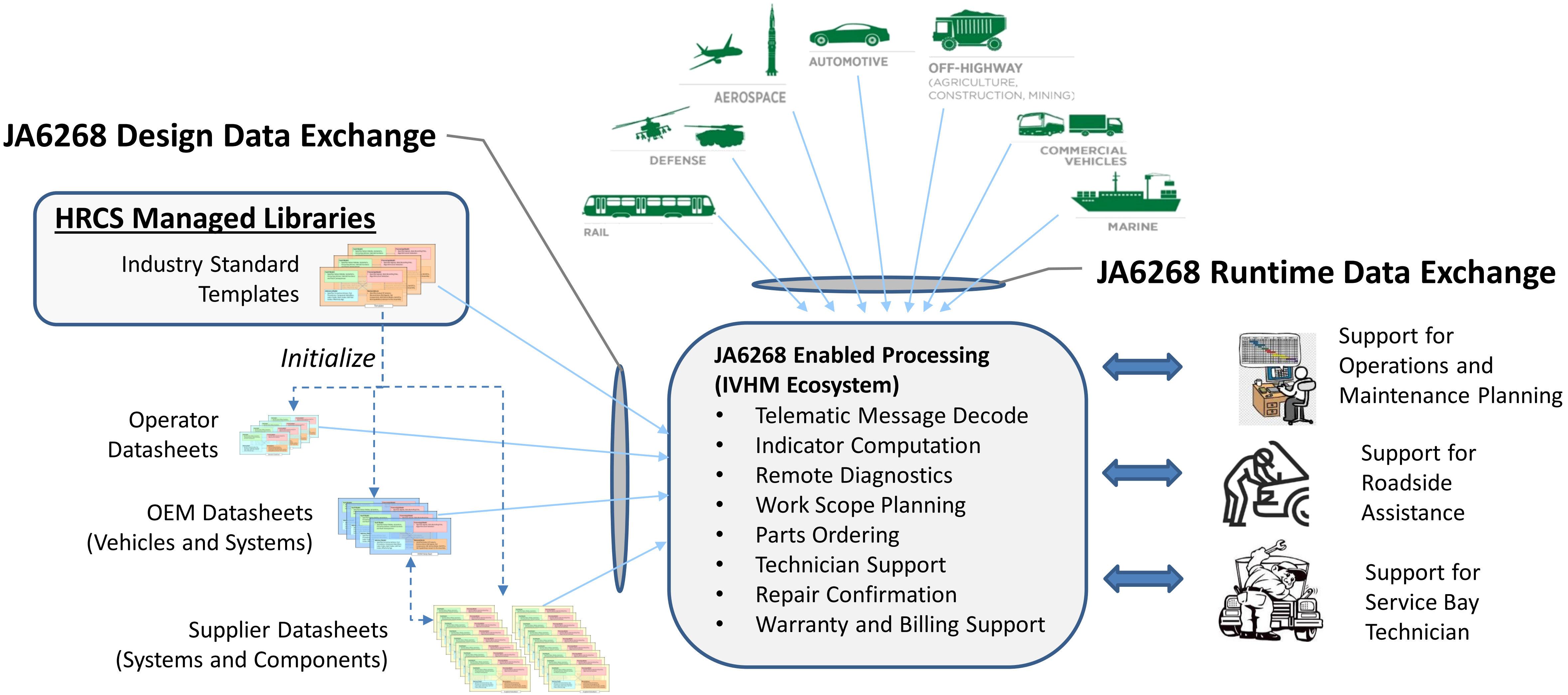
SAE INTERNATIONAL

| 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.

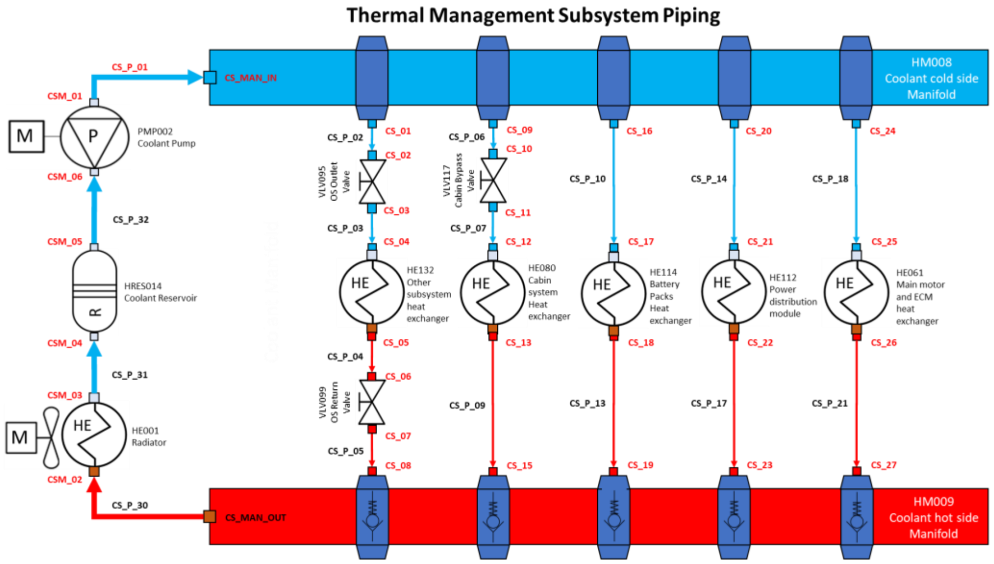
# JA6268 Application Overview




**JA6268 format and vocabulary aligned with industry standards (e.g.: J1939, J2012, J1979, etc.)**

# Using Application Design Data

## Schematic in Drawing Tool – Thermal Management Piping




*All commercial schematic drawing tools can export a NetList*

## Schematic NetList

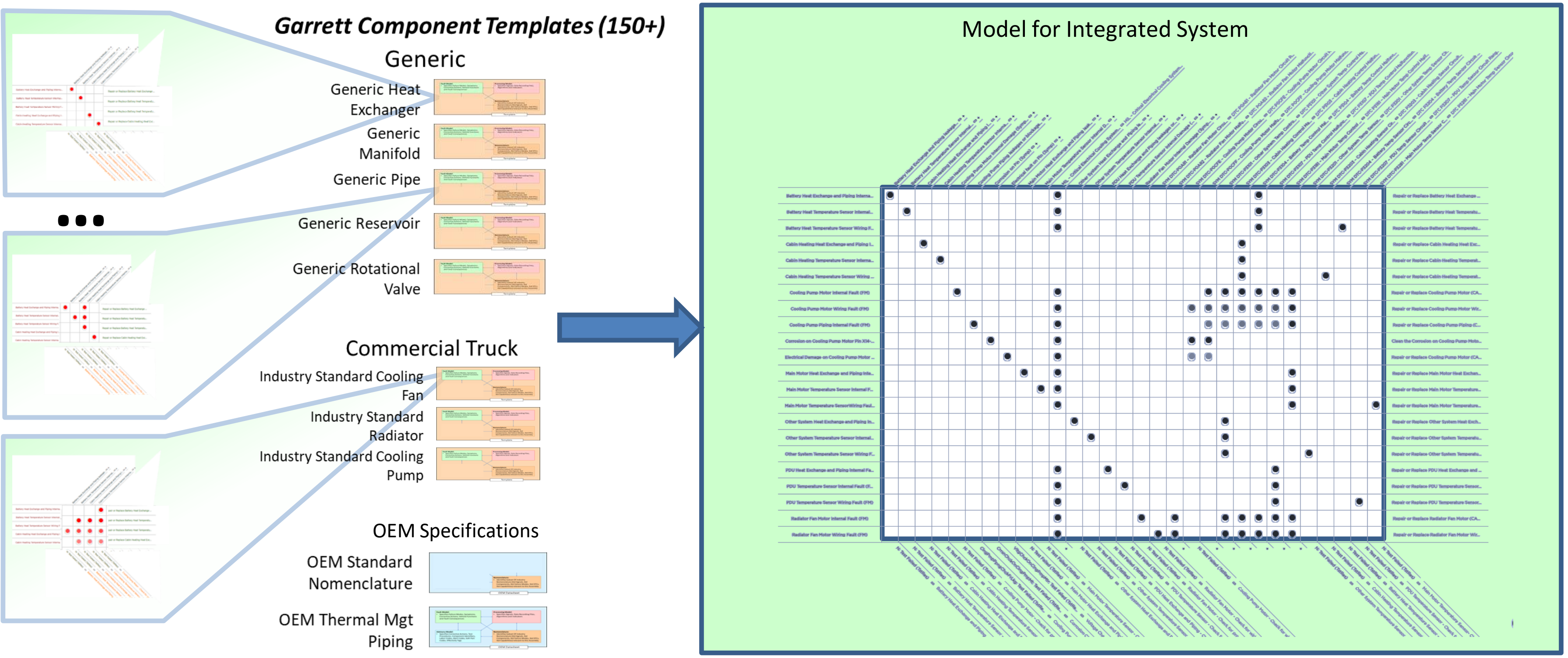
| ComponentInstanceCode_Source | ConnectorInstanceCode_Source | Pin_Source | ConnectionInstanceCode | Signal | MessageCode | ComponentInstanceCode_Destination | ConnectorInstanceCode_Destination |
|---|---|---|---|---|---|---|---|
| PMP002 | CSM_01 | | CS_P_01 | | | HM008 | CS_MAN_IN |
| HM008 | CS_01 | | CS_P_02 | | | VLV095 | CS_02 |
| VLV095 | CS_03 | | CS_P_03 | | | HE132 | CS_04 |
| HE132 | CS_05 | | CS_P_04 | | | VLV099 | CS_06 |
| VLV099 | CS_07 | | CS_P_05 | | | HM009 | CS_08 |
| HM008 | CS_09 | | CS_P_06 | | | VLV117 | CS_10 |
| VLV117 | CS_11 | | CS_P_07 | | | HE080 | CS_12 |
| HE080 | CS_13 | | CS_P_09 | | | HM009 | CS_15 |
| HM008 | CS_16 | | CS_P_10 | | | HE114 | CS_17 |
| HE114 | CS_18 | | CS_P_13 | | | HM009 | CS_19 |
| HM008 | CS_20 | | CS_P_14 | | | HE112 | CS_21 |
| HE112 | CS_22 | | CS_P_17 | | | HM009 | CS_23 |
| HM008 | CS_24 | | CS_P_18 | | | HE061 | CS_25 |
| HE061 | CS_26 | | CS_P_21 | | | HM009 | CS_27 |
| HM009 | CS_MAN_OUT | | CS_P_30 | | | HE001 | CSM_02 |
| HE001 | CSM_03 | | CS_P_31 | | | HRES014 | CSM_04 |
| HRES014 | CSM_05 | | CS_P_32 | | | PMP002 | CSM_06 |

## Assembly List / OEM Standard Data

| Inherits From: | Assembly Name | Assembly Code | Assembly Abbreviation |
|---|---|---|---|
| GTHC008 Generic Heat Exchanger | Battery Heat Exchanger | HE114 | CSBattHE |
| GTHC008 Generic Heat Exchanger | HVAC (Cabin Heat) Heat Exchanger | HE080 | CSHVACHE |
| GTHC008 Generic Heat Exchanger | Main Motor Heat Exchanger | HE061 | CSHVMotHE |
| GTHC008 Generic Heat Exchanger | Other System Heat Exchanger | HE132 | CSOSHE |
| GTHC008 Generic Heat Exchanger | PDU Heat Exchanger | HE112 | CSPDUHE |
| GHYC002 Generic Manifold | Coolant Cold Side Manifold | HM008 | CSMnfld |
| GHYC003 Generic Manifold w Chk Valves | Coolant Hot Side Manifold | HM009 | CSMnfld |
| GHYC001 Generic Pipe | Battery Packs Cold Side (Inlet) Pipe | CS_P_10 | CSBattHExDscgPp |
| GHYC001 Generic Pipe | Battery Packs Return Hot Side (Dscg) Pipe | CS_P_13 | CSBattHExInltPp |
| GHYC001 Generic Pipe | Cabin Bypass Valve Cold Side (Inlet) Pipe | CS_P_06 | CSCabBPVlvInPp |
| GHYC001 Generic Pipe | Cabin Bypass Valve Cold Side Outlet (Dscg) Pipe | CS_P_07 | CSCabBPVlvDscgPp |
| GHYC001 Generic Pipe | Coolant Pump Inlet Pipe | CS_P_32 | CSPumpInPp |
| GHYC001 Generic Pipe | Coolant Pump Manifold Cold Side (Inlet) Pipe | CS_P_01 | CSPumpMFldInPp |
| GHYC001 Generic Pipe | Coolant Pump Manifold Return Hot Side Pipe | CS_P_30 | CSPumpDscgPp |
| GHYC001 Generic Pipe | Coolant Reservoir Clod Side (Inlet) Pipe | CS_P_31 | CSRsvrInPp |
| GHYC001 Generic Pipe | Coolant Reservoir Output (Dscg)Pipe | CS_P_32 | CSRsvrDscgPp |
| GHYC001 Generic Pipe | Main Motor Cold Side (Inlet) Pipe | CS_P_18 | CSHVMotInPp |
| GHYC001 Generic Pipe | Main Motor Hot Side (Dscg) Pipe | CS_P_21 | CSHVMotDscgPp |
| GHYC001 Generic Pipe | OS Outlet Valve Input Cold Side (Dscg) Pipe | CS_P_02 | CSOSOutVlvInPp |
| GHYC001 Generic Pipe | OS Outlet Valve Output Cold Side (Inlet)Pipe | CS_P_03 | CSOSOutVlvDscgPp |
| GHYC001 Generic Pipe | OS Return Valve Input Cold Side (Inlet) Pipe | CS_P_04 | CSOSRtnVlvInPip |
| GHYC001 Generic Pipe | OS Return Valve Output Hot Side (Dscg) Pipe | CS_P_05 | CSOSRtnVlvDscgPip |
| GHYC001 Generic Pipe | Power Distribution Module Cold Side (Inlet) Pipe | CS_P_14 | CSPDUInPp |
| GHYC001 Generic Pipe | Power Distribution Module Return Hot Side (Dscg) Pipe | CS_P_17 | CSPDUDscgPp |
| GHYC001 Generic Pipe | Radiator Cool Side (Inlet) Pipe | CS_P_30 | CSRadInPp |
| GHYC001 Generic Pipe | Radiator Hot Side Pipe (Dscg) | CS_P_31 | CSRadOutPp |
| GHYC013 Generic Reservoir | Coolant Reservoir | HRES014 | CSRsvr |
| GHYC006 Generic Rotational Valve | Cabin Bypass Valve | VLV117 | CSCabBPVlv |
| GHYC003 Generic Rotational Valve | Other System Outlet Valve | VLV095 | CSOSOutVlv |
| GHYC005 Generic Rotational Valve | Other System Return Valve | VLV099 | CSOSRtnVlv |
| STHC012 Standard Radiator | Radiator | HE001 | CSRadHE |
| SVTH001 Standard Coolant Pump | Coolant Pump | PMP002 | CSPump |

**Existing System Design Data Identifies Component List and Provides Application Specific Connectivity Information**

# Use of 6268 Data to Derive Fault Model Content




**Templates and Datasheets include Fault Model data that is combined for complete application to provide comprehensive guided diagnostic capability.**

# Use of 6268 Data for Analytics and Prognostics

OEM Standard Nomenclature

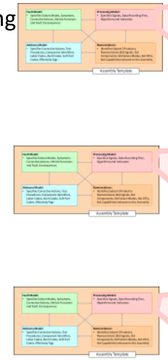
OEM Thermal Mgt Piping

OEM Vehicle X Comm Topology

OEM Vehicle X Thermal Mgt Electrical Schematics

OEM Vehicle X Power / Ground Schematics

*System Files Translate Component Signals to System Signals which are Mapped to Standard Signals*



Standard Cooling Pump

Regimes
- Pump Off
- Pump Start
- Pump Steady
- Pump Stop

Data Recordings:
- Pump Start Fluid Dynamics
- Pump Start Electrical Dynamics

Algorithms:
- Time to Prime
- Pump Motor Start Torque and Speed
- Pump Motor Winding Health

Generic Valve

Regimes
- Valve Closed
- Valve Opening
- Valve Open
- Valve Closing

Data Recordings:
- Valve Opening
- Valve Closing

Algorithms:
- Valve Actuation Performance

Generic Solid State Circuit Breaker

Regimes
- Breaker Closed
- Breaker Opening
- Breaker Open
- Breaker Closing

Data Recordings:
- Breaker Opening
- Breaker Closing

Algorithms:
- Breaker Actuation Performance

*Component Files Define Regimes, Data Recordings, Algorithms and Indicators*

**Regimes**
- Pump Start
- Valve Actuation
- Breaker Closing

**Data Recording Files**
- Pump Start Fluid Dynamics
- Pump Start Electrical Dynamics
- Valve Actuation Fluid Dynamics
- Solid State Relay Transient Recording

**Algorithms**
- Time to Prime
- Pump Motor Start Torque and Speed
- Pump Motor Winding Health
- Valve Actuation Performance
- Valve Electrical Performance

**Indicators (Condition, Health, Predictive, Usage)**
- Time to Prime
- Pump Start Fluid Dynamics
- Pump Start Electrical Dynamic
- Valve Actuation Performance
- Valve Electrical Performance

**Templates and Datasheets include Processing Model data that is combined to automate key aspects of data recording, transmittal and algorithm execution to produce additional indicators that can be used for diagnostics or prognostics**

# JA6268 Technical and Programmatic Status

- HRCS is developing substantial library of templates for Generic and Industry Standard Components, Functions and Systems.
- JA6268 is being used with major Trucking OEM as basis for next generation IVHM functionality and integration of supplier data and supplier IVHM services.
- JA6268 is being used by American Trucking Association – Technology and Maintenance Council (ATA-TMC) as process to development of new requirement documents for IVHM interfaces and functions.
- JA6268 has been subject of demonstration programs for US Army and Navy and is currently being assessed as basis for asserting IVHM requirements for future programs.
- JA6268 is being used by a major automotive Tier 1 to implement the IVHM functionality for their next-gen products.

# Tim's Questions for Audience Delight

1. Do you think JA6268 will be of greatest value to Operators, OEMs, Suppliers, Other?

2. **Can you think of ways that the value of JA6268 can be increased to each participant?**

   **Slido audience response:**

   1. **Collaborations**
   2. **Communications**
   3. **Performance monitoring**
   4. **OEM requirements**
   5. **Online tutorial**
   6. **Real case studies**

3. What do you see as possible impediments to the success of JA6268?

# Advancing PHM for Manufacturing Operations through Standards

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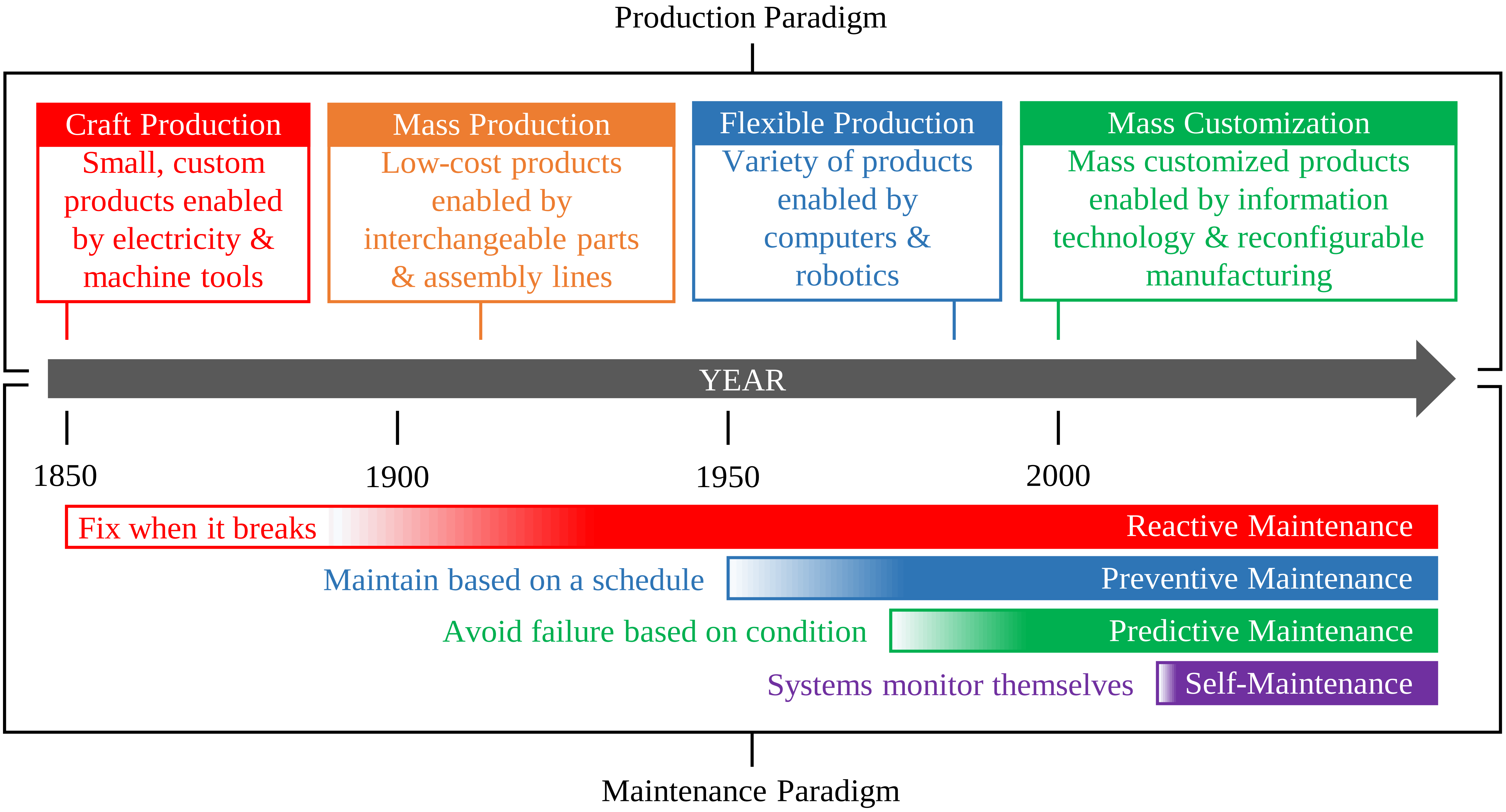
# Advanced Manufacturing Enables…

- Make what you want, where you want it, and when you want it.
- Respond in real time to meet changing demands and conditions
- Easily and rapidly reconfigure factory production to optimize performance
- Deal with uncertainty and anomalies to enable continuous improvement
- Maintain seamless interoperability




Gregory W. Vogl, Brian A. Weiss, and Moneer M. Helu, "A Review of Diagnostic and Prognostic Capabilities and Best Practices for Manufacturing," *Journal of Intelligent Manufacturing*, 2016.

# Reducing Barriers to PHM Adoption…

- Aid manufacturers in designing, deploying, verifying, and validating PHM strategies within their manufacturing operations

# ASME PHM Subcommittee Charter

NIST

*Develop standards and guidelines that advance the design and implementation of monitoring, diagnostic, and prognostic capabilities, along with ways of verifying and validating their performance, to* ***enhance adaptive maintenance and operational control strategies*** *within manufacturing.*

ASME
SETTING THE STANDARD

# Guiding Manufacturers in Determining where to Advance Maintenance Practices

NIST

- Challenge: Manufacturers are constantly challenged in trying to optimize their maintenance activities. Unhealthy processes can impact quality. Likewise, unscheduled or frequent downtime impacts productivity and production costs.

- Solution: A “Guideline for Manufacturing Prognostics and Health Management (PHM): Determining PHM Inclusion in Factory Operations” has been developed by an ASME Subcommittee.

- What it Provides: The guideline assists manufacturers in making decisions about when and where to integrate monitoring, diagnostic, and prognostic tools and systems in their facilities to ideally optimize maintenance of their manufacturing operations and/or improve their production planning.

Example Data Catalog Format

| Parameter | Asset | Data Item Type | Sensor Type | Sensor/ Data Characteristics | Signal Conditioning /Processing |
|---|---|---|---|---|---|
| Identifies the parameter of interest (e.g. vibration, pressure, current, etc.) | Identifies the asset being examined for relevant PHM data (e.g. pump, motor, etc.) | Identifies the Data Item Type relevant to PHM (e.g., attribute, measurement, command, control or state) | Identifies the type of sensor needed to measure the parameter of interest (e.g. proximity probe, strain gauge, etc.), along with any relevant features (e.g. range, resolution, etc.) desired. | Discrete/ Parametric, Sampling/ Update Rate:(1 Hz, 10Hz, etc.)<br><br>Data Resolution (e.g., Range, Least Significant Digit)<br><br>Sampling Logic (e.g., Continuous, on-demand, event-driven) | Identifies any needs for conditioning of the signal (e.g., amplification, attenuation, filtering, etc.) |

# Guiding Manufacturers in Determining where to Advance Maintenance Practices

NIST

- Collaborate:
  - Provide feedback on the guideline's practicality and viability
  - Pilot the guidelines in manufacturing facilities to offer lessons learned, areas of success, and shortcomings

- Benefits/Impact:
  - Early access to the draft document will enable reviewers to include their input and perspective which will broaden applicability and increase practicality in the manufacturing community
  - Early adoption and deployment of the guidelines will offer those specific collaborators a 'head-start' (i.e., competitive advantage) in enhancing their maintenance practices.

# Questions for the Audience

NIST

- What do you see as the PHM Society's role in the standards community?
- What are the barriers to the manufacturing community adopting standards? (word cloud poll not conducted because of time)
- What existing PHM standards do you see as most valuable to the manufacturing industry?

phmsociety

Use Slido for your questions and to like others

… but do ask questions or comment (community chat)

You can raise your hand in Zoom

# Discussion

1. What new existing and new standards are coming from the main standards developing organizations?
2. How to contribute and identify gaps?
3. How could the PHM Society help?

We'll conclude by re-asking you to rank the priorities **RANKING POLL**

# *Audience Priorities Slido Poll*



>> Higher for priority 1 and lower for others

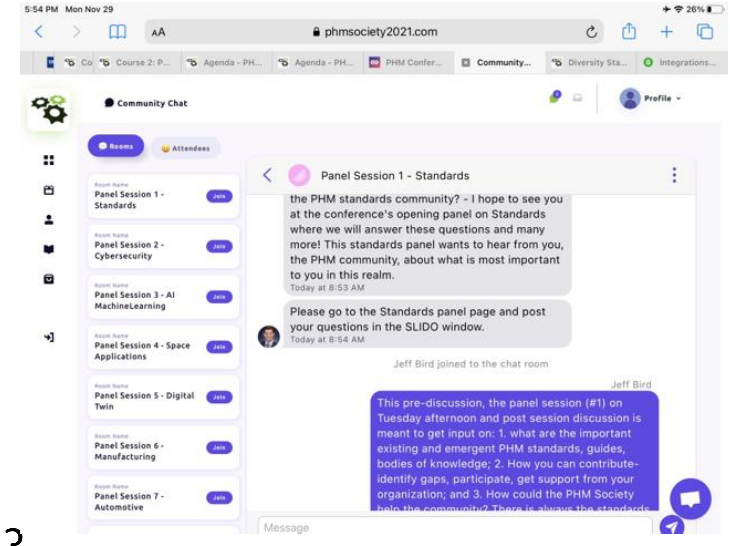
# Discussion for the Conference Hub Chat

1. An open question for those that attended yesterday's Standards panel - what could have been done differently or improved in a future Standards panel offering? More time for discussion? More speaker presentation on a specific topic? Something else? All thoughts are welcome
2. There is usually a standards panel every year in PHM with similar content. Maybe having a PHM resource page summarizing much of the related standards, and focusing the standards panel on what's new in the standards world, not just development but emerging needs and anything else { see the upcoming standards portal on phmsociety.org}
3. Valuable central resource. Another idea is to have a theme around standards each year - for instance, standards for innovation and scaling. We know that standards are a (often viewed as not sexy) requirement for large scale PHM deployment , what are some specific examples?
4. Another consideration here is that we always talk about standards gaps and what standards can be developed to fill these gaps. I think the community should also spend some time in reviewing existing standards to determine which are out of date that should be identified for revision/update. It's also possible that some standards may need to be sunset (if not revised).
5. Thanks for your time and participation. Standards seems to be not flashy but I am encouraged at the response from the community for this annual panel. It regularly here and in Europe is one of the most well attended. I think people understand that it is one significant source of the body of knowledge in this dynamic field, albeit one with some lag and maybe not a broad engagement. The Standards portal was developed more than a year ago but we have been waiting for that time for the website upgrade. I think we are close to standing it up.

phmsociety

# Way Forward- Get Involved!

- IJPHM papers and communications
  Indexed in the Emerging Sources Citation Index
  - Submit an abstract
  - Submit an abstract for the Standards Special Issue
- Updates on standards in progress
  - *PHM Standards Portal* - what else would be useful there?
  - Standards Users Group - join
  - Forum discussions - participate
- Standards Review Process
  - *PHM-ISO connect:* want to help?
  - Other Standards Development Organizations- want to help?
- What else would be useful?
  Standards forum: [https://www.phmsociety.org/forum/592](https://www.phmsociety.org/forum/592)




**Please visit and participate in the PHM21 discussion group on Hub Community Chat**.

Thank you
Hope to see you in Turin in 2022 for PHME22

**SESSION SURVEY POLL**

# *Audience Wrap-up Slido Poll*

| Evaluation Question | Ranking 1 to 5 (Limited Responses) |
| --- | --- |
| The session provided new information to me | 4 |
| The session will help me in my research/job | 3.7 |
| I would attend a similar session (virtual or live) in the future for more updates | 3.3 |
| I would participate in a PHM Standards Users' Group organized by the PHM Society | 4.3 |