



# ***Health-Ready Components & Systems***

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September 25, 2019



***Collaborative Innovation.  
Trusted Implementation.***

# HEALTH-READY COMPONENTS & SYSTEMS (HRCS) CONSORTIUM

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- Based on SAE JA6268™ – **Design and Run-Time Information Exchange for Health-Ready Components**, released April 2018
- Consortia Background
  - HRCS fosters improvements in performance, reliability, cost reduction & safety\*
  - Potentially required technology for Autonomous Vehicles and Aircraft (?)
  - Closely aligned with Digital Thread trend
  - Multi-sector, high overlap with Auto and Aero
  - Other sectors including manufacturing
- 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, higher visibility to HRCS components
  - Part Suppliers – field performance data feedback, standardized protocols, and visibility to customers
  - Research Organizations
- Why now? – Drive use of standard before market fragments

# HRCS FOCUS: MOBILITY (ALSO APPLICABLE TO FIXED-BASE EQUIPMENT, E.G., MFG.)



# ORIGINATING DOCUMENT: SAE JA6268™










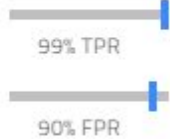








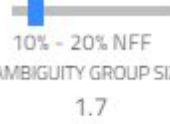

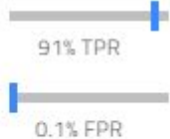










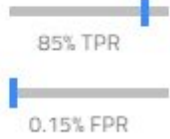








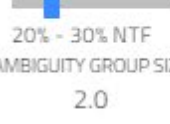

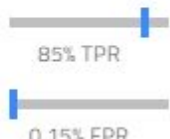








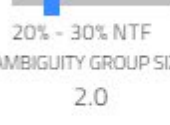

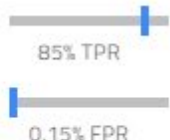



<b>SURFACE VEHICLE/AEROSPACE RECOMMENDED PRACTICE</b>	<b>JA6268™</b>	<b>APR2018</b>
	Issued	2018-04
Design & Run-Time Information Exchange for Health-Ready Components		

## RATIONALE

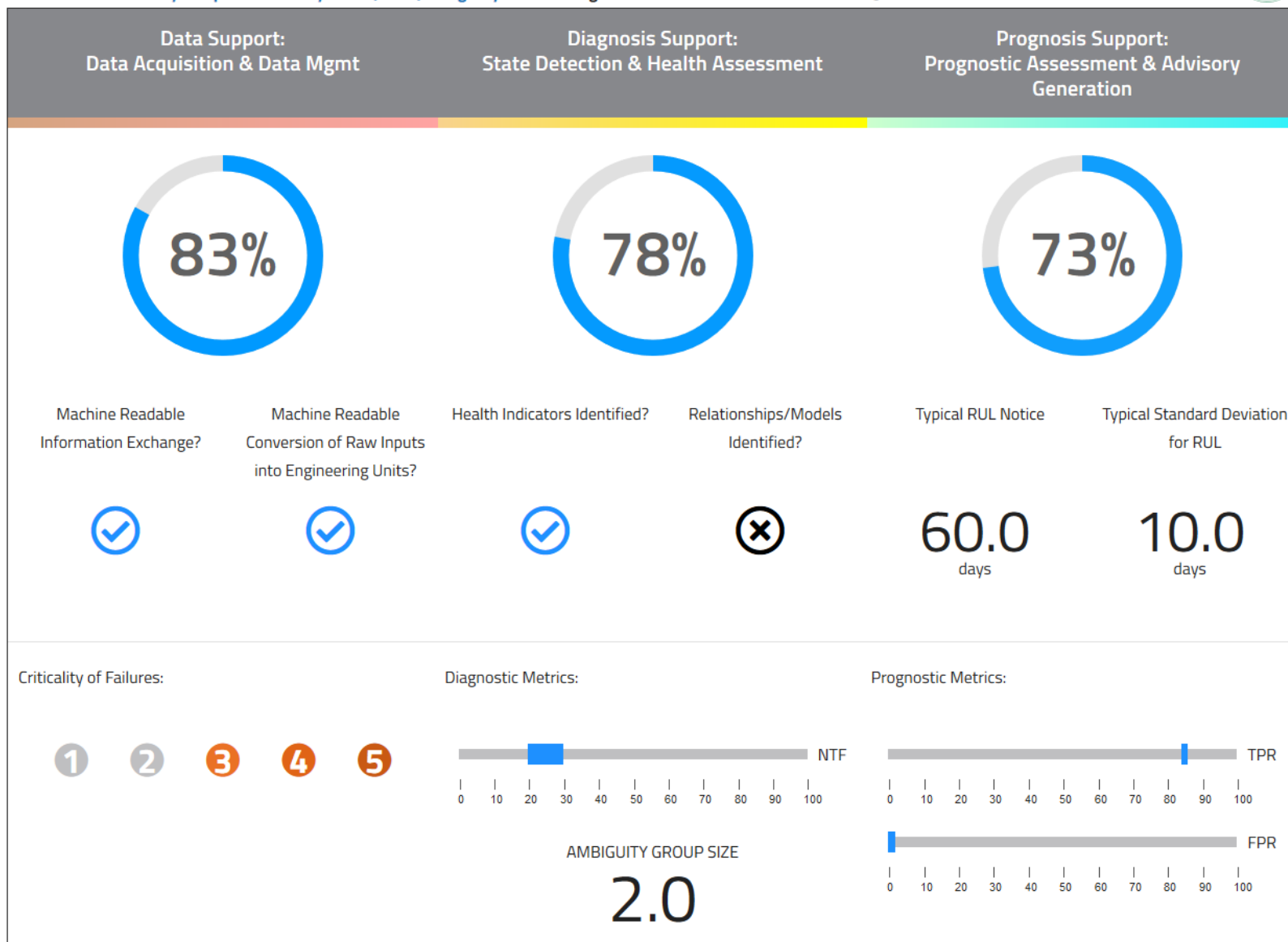
This Surface Vehicle & Aerospace Recommended Practice was created to help reduce existing barriers to the successful implementation of Integrated Vehicle Health Management (IVHM) technology into the aerospace and automotive sectors by introducing health-ready components. Health-ready components are augmented 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.

Source: [https://www.sae.org/standards/content/ja6268\\_201804/](https://www.sae.org/standards/content/ja6268_201804/)

Part Name	Supplier Name	Sector	Stage	Machine Readable Info Exchange	Machine Readable Conv of Input to Eng Units	Criticality of Failures	Data Acquisition & Manipulati... Coverage	Health Indicators ID'd	Relationship / Models ID'd	Diagnostic Metrics	State Detection & Health Assessment Coverage	Typical RUL Notice	Typical RUL Std Dev	Prognostic Metrics	Prognostics Assessment & Advisory Generation Coverage
Electric Power Steering	Nexteer Automotive	Automotive								 70% - 80% CdC				 99% TPR 90% FPR	
Turbocharger with Electric Boost - 891839-0001	Garret	Automotive								 10% - 20% NFF AMBIGUITY GROUP SIZE 1.7		30.0 days	10.0 days	 91% TPR 0.1% FPR	
Turbocharger with Variable Nozzle Turbine - 873767-50015	Garret	Automotive								 20% - 30% NTF AMBIGUITY GROUP SIZE 2.0		60.0 days	10.0 days	 85% TPR 0.15% FPR	
Turbocharger with Variable Nozzle Turbine - 830323-50035	Garret	Automotive								 20% - 30% NTF AMBIGUITY GROUP SIZE 2.0		60.0 days	10.0 days	 85% TPR 0.15% FPR	
Turbocharger with Variable Nozzle Turbine - 830323-50065	Garret	Automotive								 20% - 30% NTF AMBIGUITY GROUP SIZE 2.0		60.0 days	10.0 days	 85% TPR 0.15% FPR	

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Turbocharger	XYZ Co	Automotive								70% - 90% CdC 50% NTF		60.0 Days	15.0 Days	99% TPR 90% FPR	
Antilock Brake Module	Stop Co	Aerospace								10% - 20% NFF AMBIGUITY GROUP SIZE 1.9		2.0 Weeks	1.0 Weeks	91% TPR 0.1% FPR	
Infortainment	Entertain Co	Aerospace								20% - 30% NTF AMBIGUITY GROUP SIZE 4.0		120.0 Hours	24.0 Hours	85% TPR 0.15% FPR	
Auxilliary Power System	Power Co	Aerospace								20% - 50% NFF 70% - 90% FDR		80.0 Operation Hours	10.0 Operation Hours	75% TNR 0.4% FNR	
Landing Gear	Land Co	Automotive								10% - 30% NTF		240.0 Engine Hours	12.0 Engine Hours	66% PPV 4% NPV	
Power Take Off	Power Co	Off-Highway								30% - 60% NTF		3.0 Months	1.0 Months		

<https://hrcs.sae-itc.org/previewAtPHMSociety2019>




https://  
hrcs.sae-itc.org/  
previewAtPHMSociety2019

**SAE ITC** Health-Ready Components & Systems (HRCS) Registry (Alpha)

SAE ITC > Health-Ready Components and Systems (HRCS) > Registry > Electric Power Steering Nexteer Automotive

Data Support: Data Acquisition & Data Mgmt      Diagnosis Support: State Detection & Health Assessment      Prognosis Support: Prognostic Assessment & Advisory Generation

**Assembly Details** [X]


<b>Component Name</b> <b>Electric Power Steering</b>			
<b>Known Aliases</b> EPS	<b>Catalog Reference Number(s)</b>	<b>Primary Validation Approach</b> Combined Design & Run-Time Info	<b>Format of Health-Ready Information</b> MS Word templated tables
<b>Supplier Name</b> Nexteer Automotive	<b>Sector</b> Automotive	<b>Date Validation Certified</b> 3/25/2019	<b>Date Validation Expires</b> 3/25/2024
<b>DUNS Number</b> 00-025-7923	<b>CAGE Number</b> N/A	<b>Validating OEM/Integrator/Operator</b>	
<div style="border: 1px solid #ccc; padding: 5px; margin-bottom: 5px;"> <p><b>Supplier Contact</b></p> <p>Matt Tompkins      @ matthew.tompkins@nexteer.com  +1 (989) 757-4992</p> <p>3900 E. Holland Rd.  Saginaw, MI  48601</p> </div>		<div style="border: 1px solid #ccc; padding: 5px; margin-bottom: 5px;"> <p><b>General Motors Company</b></p> <p>Yat-Chung Tang      @ Yat-chung.tang@gm.com  +1 (586) 907-3059</p> <p>29755 Louis Chevrolet Rd.  Warren, MI  48093</p> </div>	

Machine Information      Criticality of Failure      TPR      FPR




# Building on experience with blockchain-backed database technology

<https://ts200.sae-itc.org/>



**ENGINE AND AIRFRAME STANDARDS**  
TS200 Qualified Manufacturers for SAE ITC Aerospace Industry Standard Parts (Beta)



Home About ASPQP Standards **TS200 Database** Supplier Qualification Contact

**Apply Filter** **Reset Filter**

**Manufacturer (4 Options)**

- Arconic Fastening Sy... (1)
- Bristol Industries (1)
- LISI Aerospace - Bla... (1)
- SPS Technologies - T... (1)

**Tech Spec (1 Options)**

- TS8 (4)

**Certificate # (4 Options)**

- TSSC #6 (1)
- TSSC #9 (1)
- TSSC #17 (1)
- TSSC #86 (1)

**Expiry Date (4 Options)**

- 2021 (2) ^
- April (1)
- November (1)
- 2020 (2) ^
- February (1)
- October (1)

AS27862 **Search**

Showing 1 - 4 of 4 results **Per Page:** 10

**Nut, Self Locking, Shank, Flange Restrained, Heat & CR Steel A286, Silver Coated All Over, Classification Rm ≥ 1100 MPa (160,000 lbf/in<sup>2</sup>) @ TA / +650°C**

*Part Number:* [AS27862](#)  
*Manufacturing Route Comment:* --  
*First Qualified date:* Dec 1983  
*Expiry Date:* Feb 2020  
*Technical Specification:* [TS8](#)  
*Manufacturer:* Bristol Industries  
*Location(s):* 630 East Lambert Road, Brea, California, USA, 92821  
*Certificate TSSC #:* [86](#)

**Nut, Self Locking, Shank, Flange Restrained, Heat & CR Steel A286, Silver Coated All Over, Classification Rm ≥ 1100 MPa (160,000 lbf/in<sup>2</sup>) @ TA / +650°C**

*Part Number:* [AS27862](#)  
*Manufacturing Route Comment:* --  
*First Qualified date:* Apr 1978  
*Expiry Date:* Oct 2020  
*Technical Specification:* [TS8](#)  
*Manufacturer:* SPS Technologies - T.J. Brooks  
*Location(s):* 191 Barkby Road, Troon Industrial Area, Leicester, United Kingdom, LE4 9HX  
*Certificate TSSC #:* [17](#)

**Nut, Self Locking, Shank, Flange Restrained, Heat & CR Steel A286, Silver Coated All Over, Classification Rm ≥ 1100 MPa (160,000 lbf/in<sup>2</sup>) @ TA / +650°C**

*Part Number:* [AS27862](#)  
*Manufacturing Route Comment:* --  
*First Qualified date:* Jun 1994  
*Expiry Date:* Apr 2021  
*Technical Specification:* [TS8](#)  
*Manufacturer:* Arconic Fastening Systems and Rings - Fullerton Operations  
*Location(s):* 800 South State College Blvd, Fullerton, California, USA, 92831  
*Certificate TSSC #:* [6](#)

**Nut, Self Locking, Shank, Flange Restrained, Heat & CR Steel A286, Silver Coated All Over, Classification Rm ≥ 1100 MPa (160,000 lbf/in<sup>2</sup>) @ TA / +650°C**

*Part Number:* AS27862

# HRCS WEBSITE INCLUDING MEMBERSHIP INFO

The screenshot displays the SAE ITC website for the Health-Ready Components and Systems (HRCS) Strategy Group. At the top left is the SAE ITC logo with the tagline "An SAE International Affiliate". To the right are navigation links: "Why SAE ITC", "Resources", "Industry Impact", and "Contact Us". Below the logo is a blue banner with the text "Health-Ready Components and Systems (HRCS) Strategy Group" over a background image of a turbine and a circuit board. The main content area features a large image of a multi-lane highway with several trucks and cars. Below the highway image is a navigation menu with "Membership" highlighted. To the right of the highway image are two blue boxes: "Benefits of SAE ITC" listing "Administrative & Legal", "Strategy & Operations", "Marketing & Events", "Standards & Data", and "Launch Initiative"; and "Programs" listing "AESQ Aerospace Engine Supplier Quality", "ASPQP Aerospace Standards and Part Qualification Program", and "ARINC IA". Below the navigation menu is a section titled "Health Ready Components & Systems (HRCS) Charter". At the bottom of the browser window, the URL "https://www.sae-itc.com/hracs#dexp\_tab\_item\_2113676497" is visible, along with a Windows taskbar and a system clock showing "10:11 AM 7/17/2019".

[www.sae-itc.com/hracs](http://www.sae-itc.com/hracs)

# IVHM CAPABILITY (**VEHICLE LEVEL**) (SOURCE: SAE JA6268™)

Illustrating industry evolution in use of diagnosis & prognosis for vehicle maintenance

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
<b>Manual Diagnosis &amp; Repair Process performed by Technician</b>							
<b>0</b>	Limited On-Vehicle Warning Indicators	Service actions for scheduled maintenance or when Operator notices problems or is alerted by indicator lights or simple gages.	<b>Operator/Driver &amp; Service Tech</b>	On-Vehicle Measurements & Observation	N/A	Paper-based Manuals	Only Manual Diagnostic Tools & No Condition-Based Services
<b>1</b>	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	<b>On-Vehicle &amp; Service Bay/ Depot Tools</b>	Logged Diagnostic Codes & Parameters available to Service Tech	Paper-based Manuals	On-Board Diagnostics Available
<b>2</b>	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	<b>Telematic Data Available to Service Tech with Diagnostics Info</b>	Paper-based Manuals	On-Board & Remote Data Available
<b>Diagnosis &amp; Repair Augmented by Prognosis &amp; Predictive Analytics</b>							
<b>3</b>	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	<b>Addition of Component-Level Health Models</b>	Component-Level Health Predictions
<b>4</b>	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	<b>Vehicle-Level Health Management</b>
<b>5</b>	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	<b>IVHM Capability Integrated into Vehicle Controls</b>

← For some OEMs, this could be on-board recording

# SAE JA6268™ THREE REGISTRATION STAGES (NOTE: NOW AT COMPONENT/SUBSYSTEM LEVEL)

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Ladder-like structured Stage Registrations for easy entry and upgrades when ready. No proprietary information will be requested or listed.

Stage 1: *Functional Self Assessment*

Stage 2: *Failure Modes Assessment*

Stage 3: *Detailed Design Assessment*

## Note:

- *Stage 1 is a low barrier to entry provisional registration. All Stage 1 information will be recorded in online HRCS Registry.*
- *Stages 2 & 3 are enhanced by seeking an OEM/ integrator to validate the more detailed supplier-provided assessments. Stage 2 & 3 completion will be noted in HRCS Registry. **This additional [potentially proprietary] data will not be loaded into the registry.***

# SAE HRCS HEALTH-READY COMPONENTS REGISTRY

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## Stage 1

\*All examples and associated numbers in this presentation are for illustrative purposes only.

# STAGE 1 REGISTRATION: QUICK, EASY WAY TO GET COMPONENTS LISTED

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- Provide assurance that a consistent process was followed and that the information is correct.
- Enable participants to find information they are seeking in a cost-effective manner.
- Ensure a neutral, unbiased approach.
- Provide contacts for more information or issue resolution.
- Leverage shared knowledge and technology

# ISO FUNCTIONAL REF. MODEL—ASSESSING % COVERAGE, PART A

\*(adapted for use) ISO13374-1 (2002). Condition Monitoring and Diagnostics of Machines, Geneva, Switzerland

IVHM Functional Block	Description	IVHM Process Stage
Data Acquisition (DA)	This function collects the sensor data and health state information from the equipment internal monitors, the system data bus or data recorder.	Sense
		Acquire
		Transfer
Data Manipulation (DM)	This function processes and transforms the sensor data and health state information collected by the DA.	Analyze
State Detection (SD)	This function evaluates equipment state conditions against normal operating profiles and generates normal or abnormal condition indicators.	
Health Assessment (HA)	This function provides information to determine the current state of health of equipment.	
Prognostics Assessment (PA)	This function provides future state of health, performance life remaining, or remaining useful life (usage) indicators.	
Advisory Generation (AG)	This function provides actionable information to operational and maintenance personnel or external systems.	Act

# STAGE 1: FUNCTIONAL SELF-ASSESSMENT, PART B

Part B asks [7 Supplemental Questions](#) for Covered Failure Modes Identified in Part A to quantify sophistication

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- **For Data Acquisition and Manipulation**
  - Machine readable info exchange?
  - Machine readable conversion of raw inputs into engineering units?
  - Severity of failures?
- **For State Detection & Health Assessment**
  - Health indicators identified?
  - Relationships/Models Identified?
  - Diagnostic Metrics?
- **For Prognostics Assessment & Advisory Generation**
  - Average advance notice (RUL—Remaining Useful Life)?
  - Typical Standard Deviation for RUL?
  - Prognostic Metrics?



# SAE HRCS HEALTH-READY COMPONENTS REGISTRY

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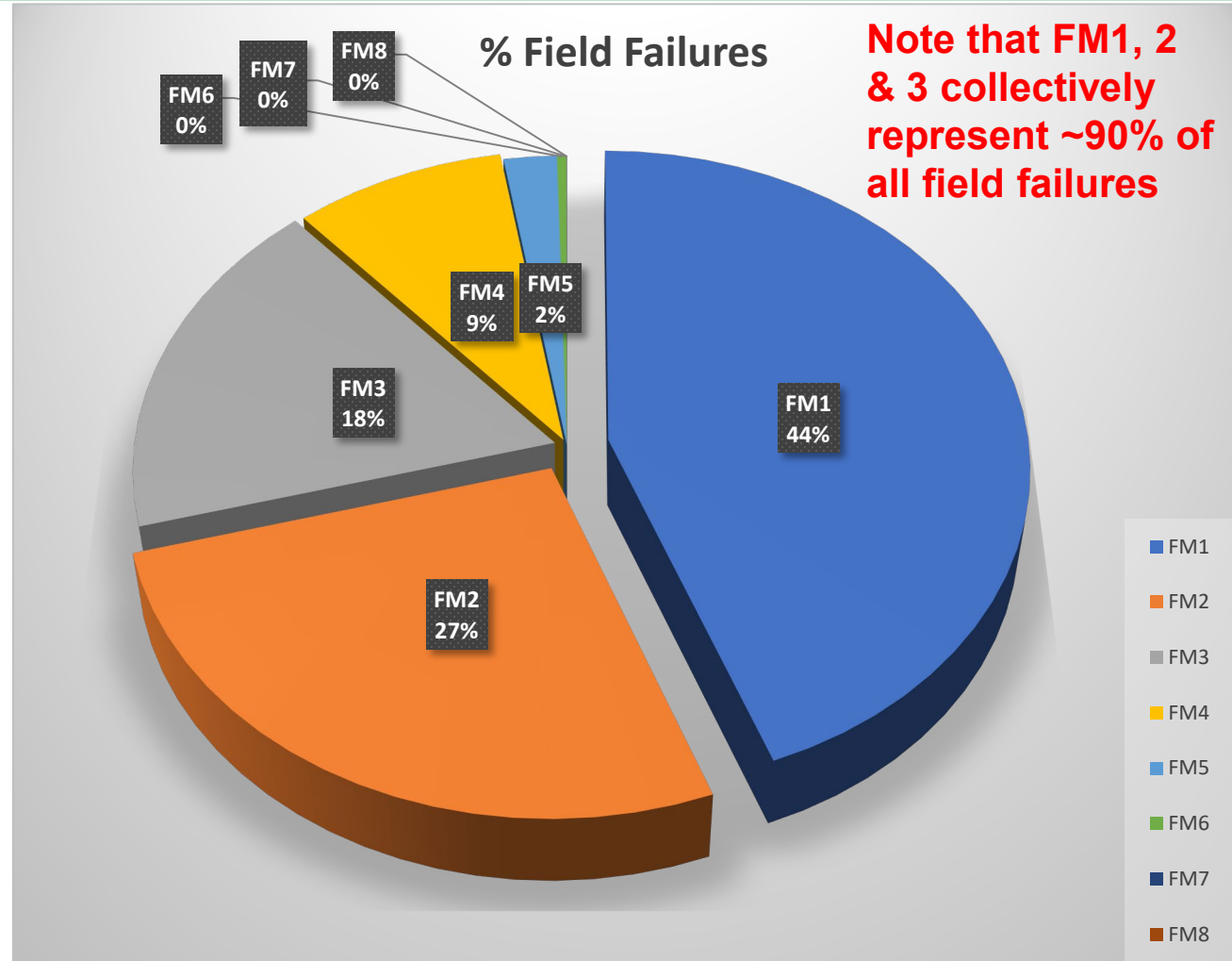
## Stage 2

\*All examples and associated numbers in this presentation are for illustrative purposes only.

# FAILURE MODES PRIORITIZED BY FREQUENCY OF OCCURRENCE (HYPOTHETICAL EXAMPLE)

Failure Mode	IPTV Expected in 1st 5* Years	% Field Failures
FM1	10.0000	44.2605
FM2	6.0000	26.5563
FM3	4.0000	17.7042
FM4	2.0000	8.8521
FM5	0.5000	2.2130
FM6	0.0900	0.3983
FM7	0.0030	0.0133
FM8	0.0005	0.0022
Total	22.5935	100.0000

\* or other reference period  
IPTV=Incidents Per Thousand Vehicles



Similar to Stage 1 but based on each individual failure mode instead of aggregate performance

# STAGE 2: FAILURE MODES ASSESSMENT

## EXAMPLE

Failure Mode Description	% Field Failures	Severity of Failure (5-1)	Avg Cost of Repairs (CPV) \$	Health Indicators ID'd (describe)	Relationships / Models ID'd (describe)	Machine Readable Information Exchange? (Y/N)	Machine Readable Conv of Raw Inputs to Eng Units? (Y/N)	Typical RUL Notice (selected units if predicted)	Diagnostic Metrics (selected type if available)	Prognostic Metrics (selected type if available)	Data Acquisition & Manipulation (DA & DM) % Coverage for Given Failure Mode	State Detection & Health Assessment (SD & HA) % Coverage for Given Failure Mode	Prognostics Assessment & Advisory Generation (PA & AG) % Coverage for Given Failure Mode	...	
1	aaaa	45	3	50	YES	YES	YES	YES	--	50	--	90	75	0	
2	bbbb	20	4	100	YES	YES	YES	YES	--	60	--	100	40	0	
3	cccc	15	5	300	YES	YES	YES	YES	--	60	--	100	30	0	
4	dddd	15	3	200	NO	NO	YES	YES	--	60	--	100	25	0	
"n"	eeee	5	2	100	NO	NO	YES	YES	--	90	--	0	0	0	
	Sum <=100%	<b>100</b>								Sums weighted by % Field Failures	<b>90.5</b>	<b>50.0</b>	<b>0.0</b>		

### Stated RUL Units:

- Hours
- Days
- Weeks
- Months
- Cycles (flights/trips/starts)
- Engine Hrs
- Operation Hrs
- Other: \_\_\_\_\_

### Diagnostic/Prognostic Performance Units\*:

- TPR/FPR
- TNR/FNR
- PPV/NPV
- FDR/FOR
- C<sub>D</sub> Coverage
- NTF (NFF)
- RUL Standard Deviation
- Other: \_\_\_\_\_

# WHY JOIN THESE EFFORTS IN THE HRCS SG?

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- Ensure **interoperable** instead of proprietary solutions
- Protection of operating in a legal, pre-competitive environment
- **Health-Ready Component Registry** gives visibility to SAE JA6268™ health-ready components and creates a cross-industry movement to implement IVHM
- 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
- Agreed upon **actions to put SAE JA6268™ into practice** by going down a level from the high-level content captured in JA6268™
- Subcommittees to tackle **terminology/lexicon/vocabulary** in important industry domains

# KEY MESSAGE!

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- Data is increasingly becoming “*the*” critical asset
  - Even when big data is available, it can be difficult to use
  - Also, we must rise from **Data → Information → Insight → Action**
- **PHM/VHM/IVHM\*** encompasses both the traditional paradigm of diagnostics and the new paradigm of prognostics
- SAE JA6268™ & HRCS lays out a future vision of how suppliers and OEMs can collaborate to mutual advantage to speed VHM implementation
- Industry Consortia can provide a complimentary mechanism to go beyond what standards alone can not accomplish



# QUESTIONS?



# THANK YOU!

