Update to SAE HM-1 on HRCS Consortium Progress

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May 2021

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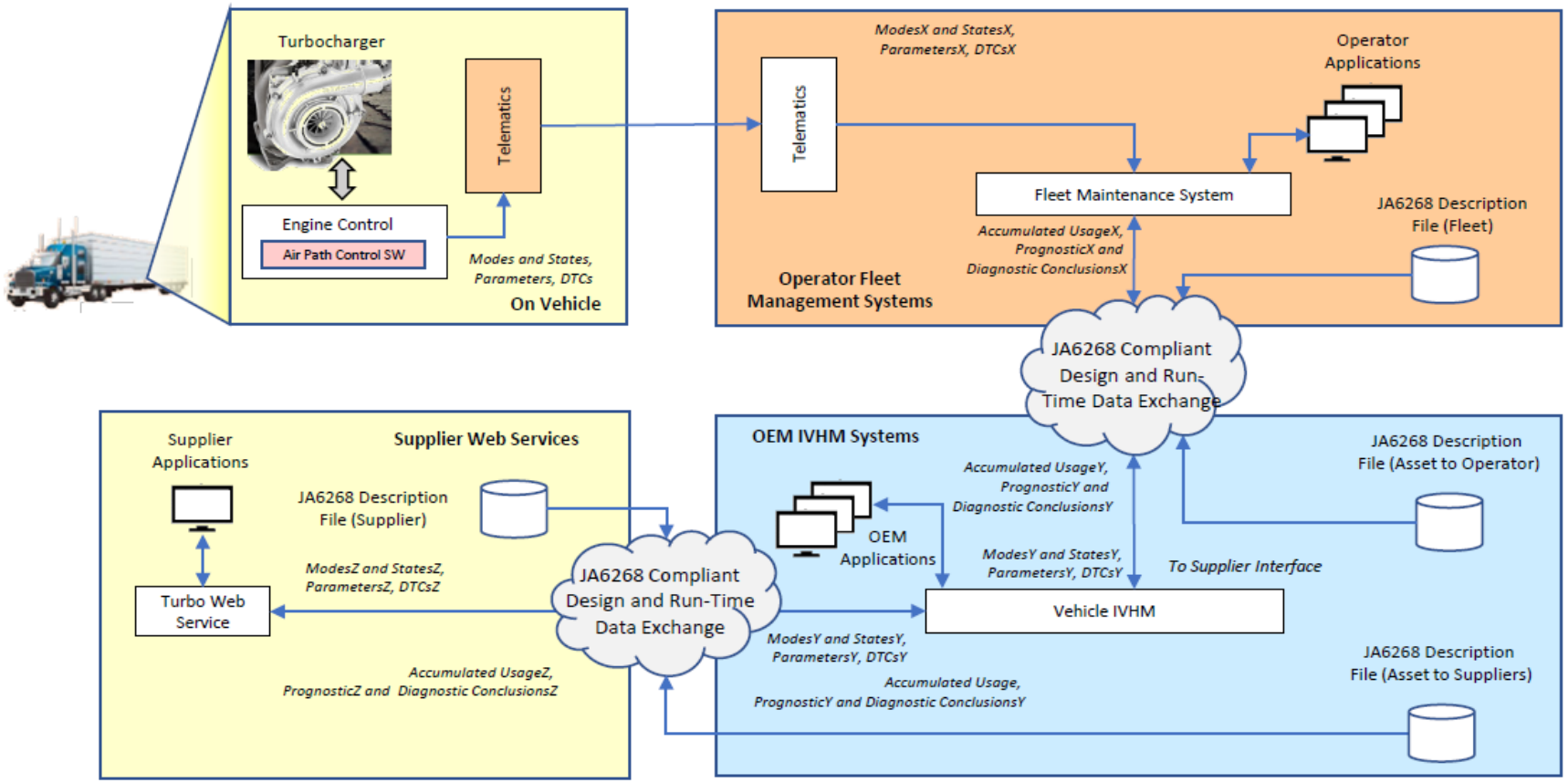
HRCS UPDATE

- Engaged with American Trucking Association (ATA) Technology & Maintenance Council (TMC)
- Launched two pilot studies (January 2021- present):
  - Volvo- Garrett- ABF Freight Lines
    - Turbo compound turbocharger and engine air system on 13L diesel engine
    - 300 Mack trucks equipped with Garrett turbochargers operated by ABF
  - SEFL- DG Technologies- Saferide Technologies
    - Primary electrical (starting) system including battery, charging system, starter, and wiring
    - Monitored 20 vehicles on a mixed fleet operated by SEFL
- Presented positive results on two public ATA Webinars and to TMC in a dedicated closed meeting
- Assigned to a Task Force (Study Group 5) to manage the HRCS-TMC process for future projects
- Next areas to be addressed: electro-mechanical braking and advanced powerplants

ATA – HRCS COMMERCIAL TRUCKING PILOT PROJECT



Volvo 13L engine with Garrett turbo-compound turbocharger

Turbocharger Parameters

- Speed of turbocharger (rpm)
- Exhaust gas inlet temperature
- Exhaust gas outlet temperature
- Wastegate position
- Oil pressure
- Oil temperature
- Knock sensor
- Engine rpm

JA6268 is used to standardize design-time data submittals, web service APIs, and run time messages

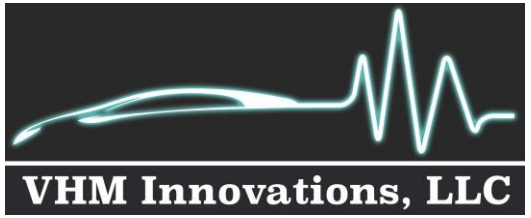
CODING AND TAXONOMY

- We realized that a standard approach is needed for different industrial sectors (Auto, Commercial Truck, Off-Highway, Aerospace, Marine, etc.). We concluded that we should use SAE source data for HRCS codes from SAE J1939, J1979, & J2012.
- This approach will support a mechanism to develop and manage standard mapping between HRCS and existing sector specific codes (such as VMRS in trucking, ATA codes in aviation, or OBD codes in automotive).
- Sector specific codes will be incorporated to accelerate acceptance and improve granularity where feasible.

HRCS ecosystem: Fleet Operators, OEMs, Suppliers

The HRCS ecosystem is growing……join us!

We are here to assist Fleet Operators, OEMs, Suppliers, and Integrators accelerate industry adoption of SAE JA6268 and IVHM.



HRCS DATABASE: 3 REGISTRATION STAGES
(NOTE: COMPONENT/SUBSYSTEM LEVEL)

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*	**Done**
Stage 2: *Failure Modes Assessment*	**Done**
Stage 3: *Detailed Design Assessment*	**In-Progress**

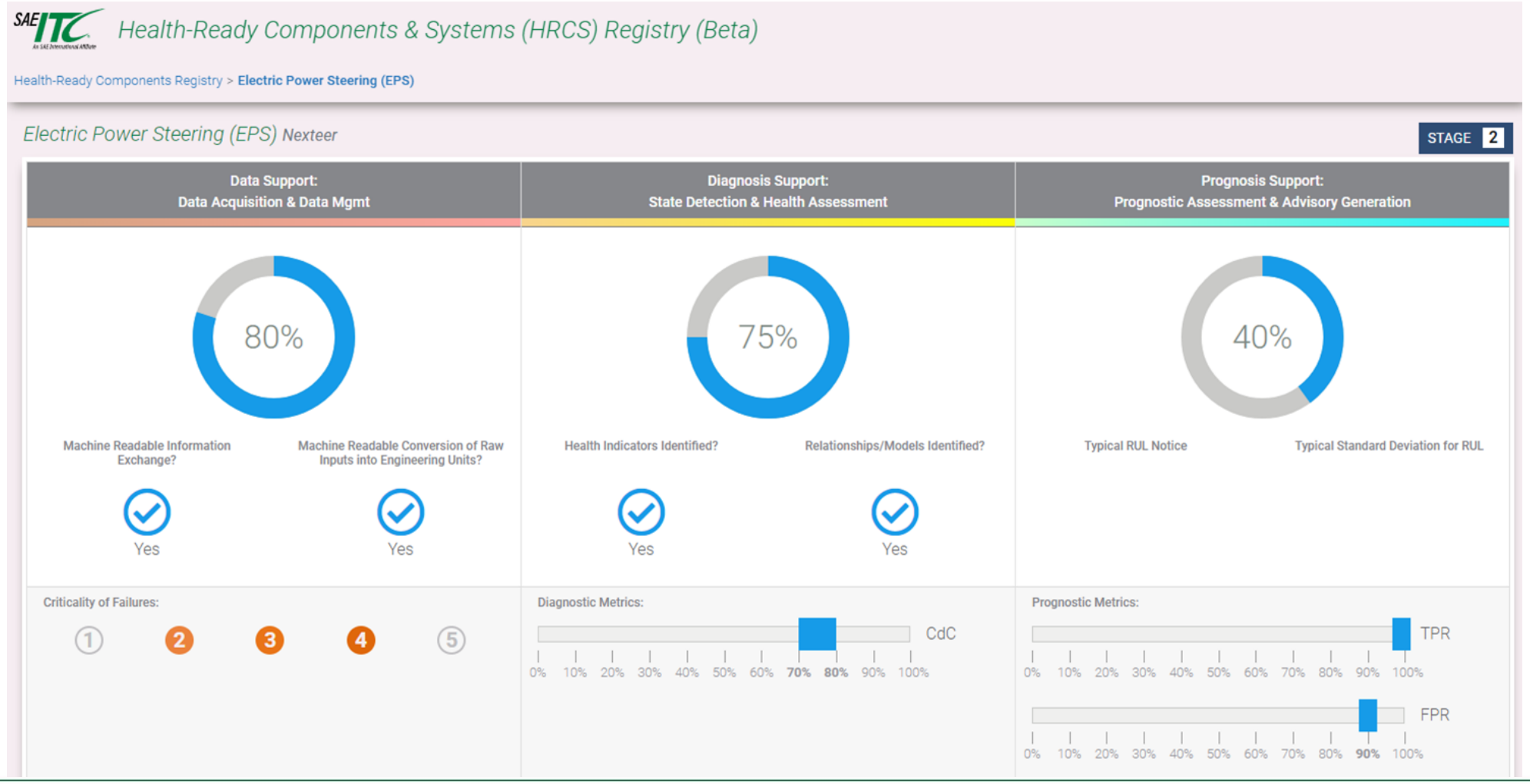
Note:

- *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.***

Link to open HRCS Registry➔ https://hrcs.sae-itc.org/

DATABASE THREE REGISTRATION STAGES
(NOTE: NOW AT THE COMPONENT/SYSTEM LEVEL)

HRCS DATABASE LISTING DETAIL



TECHNICAL APPROACH FOR REGISTRY STAGE 3

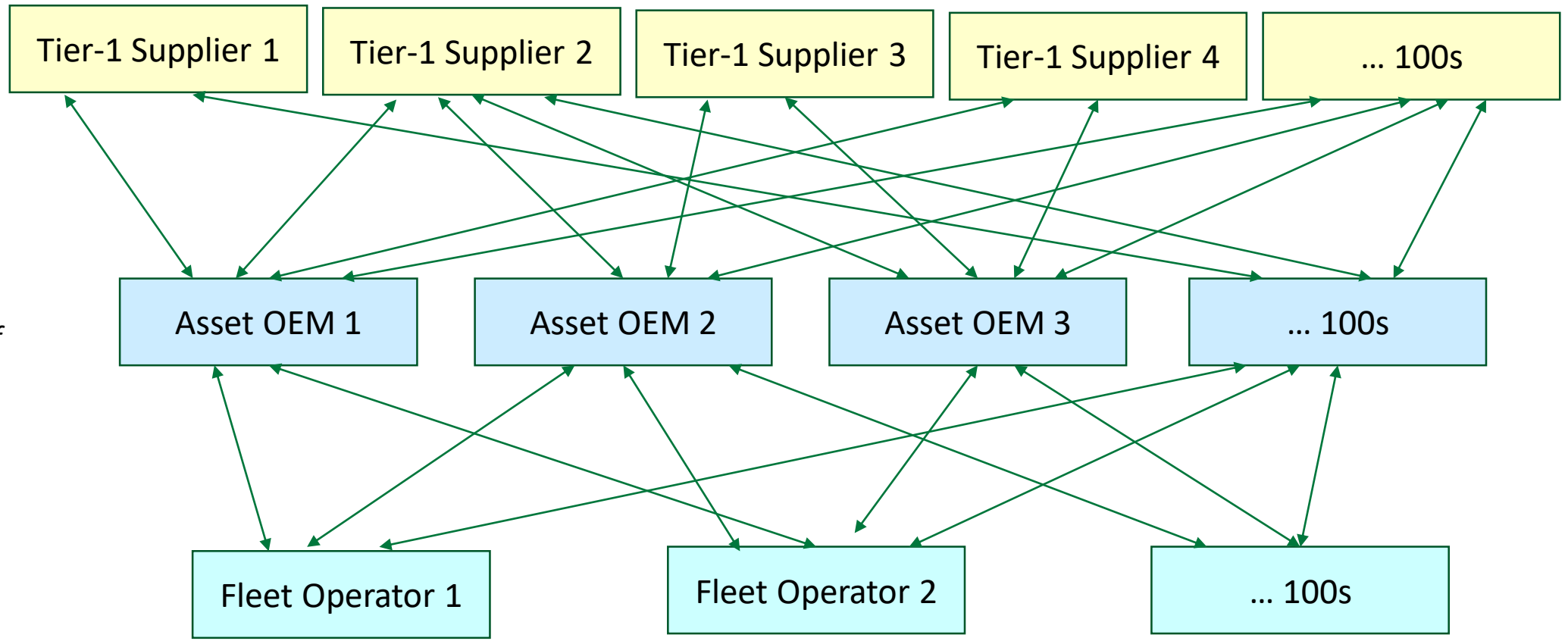
JA6268 PRIMARY USE CASE

Interoperability of IVHM functions is hampered by differences between data definitions

Each supplier must work with dozens of Integrators

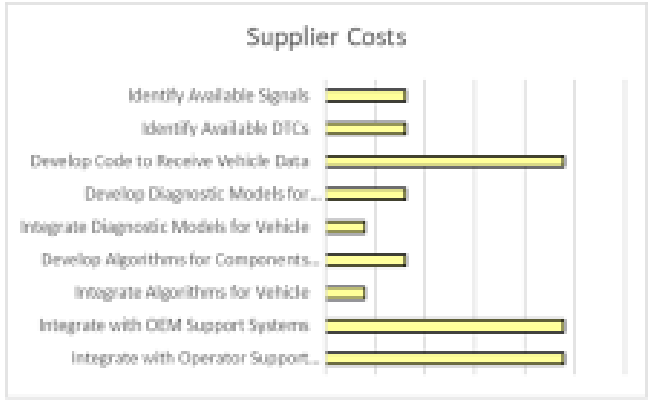
Each Integrator must work with hundreds of Suppliers and dozens of Operators

Each Operator must work with dozens of Integrators

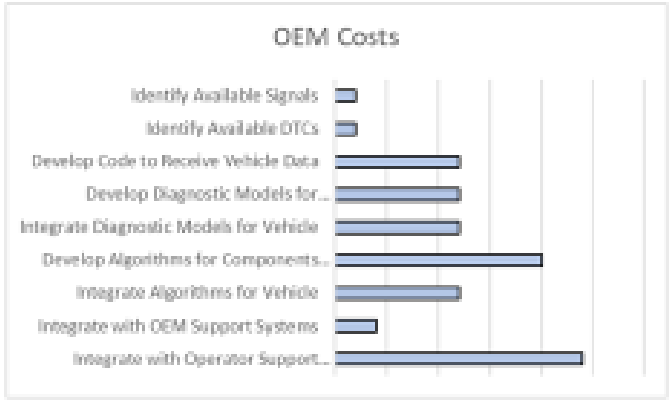


JA6268 PRIMARY USE CASE – CURRENT COSTS FACTORS

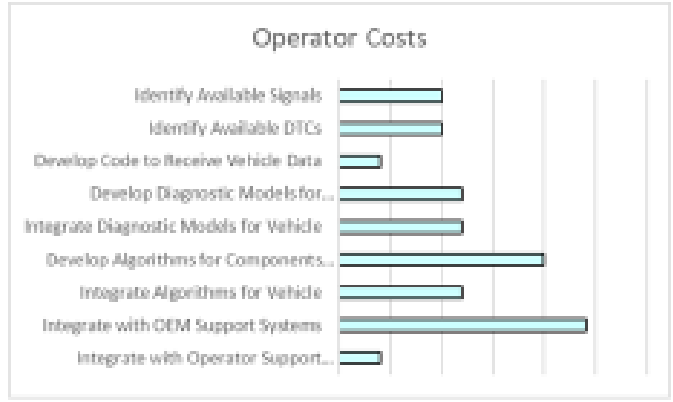
Tier-1 Supplier



Asset OEM

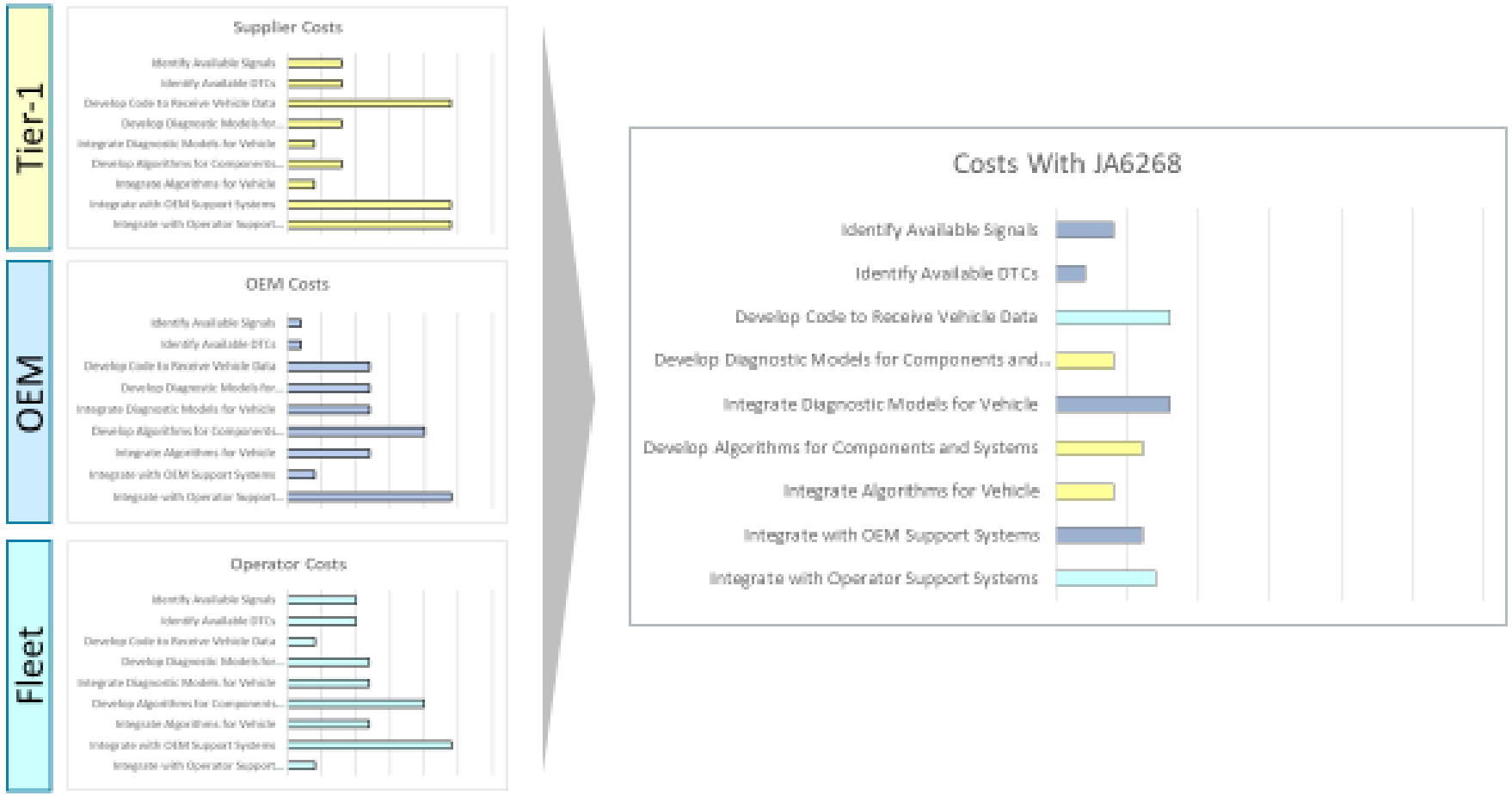


Fleet Operator



Without JA6268, organizations incur substantial costs working in areas where they are not the expert and in duplicating work of others

ENGINEERING COST SAVINGS WITH JA2628



Organizations work in areas where they are the experts and duplicated work is minimized

JA6268 substantially reduces the effort to develop highly accurate IVHM functions

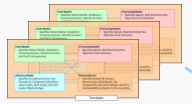
HRCS JA6268 OVERVIEW

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

JA6268 Design Data Exchange

HRCS Managed Libraries

Industry Standard Templates

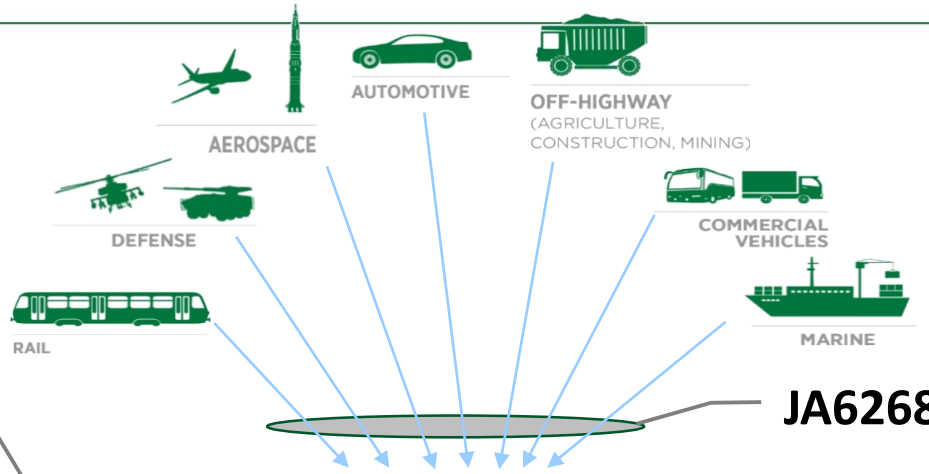


Initialize

Operator Datasheets

OEM Datasheets (Vehicles and Systems)

Supplier Datasheets (Systems and Components)



JA6268 Runtime Data Exchange

JA6268 Enabled Processing (IVHM Ecosystem)

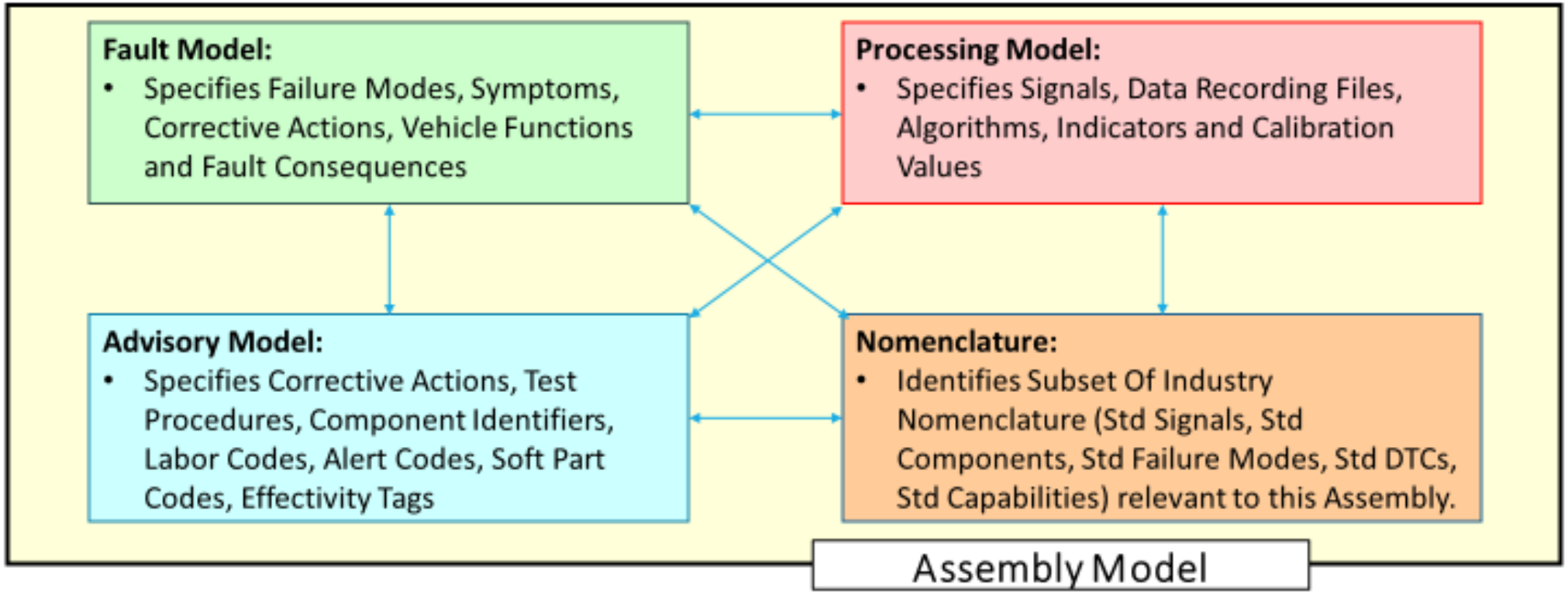
- Telematic Message Decode
- Indicator Computation
- Remote Diagnostics
- Work Scope Planning
- Parts Ordering
- Technician Support
- Repair Confirmation
- Warranty and Billing Support

Support for Operations and Maintenance Planning

Support for Roadside Assistance

Support for Service Bay Technician

JA6268 STAGE 3 DATASHEET CONTENT



Datasheets Can be Created for Components, Assemblies, Systems, etc. and at Different Levels of Detail (e.g. Industry Standard, Operator, OEM and Supplier)

USING INDUSTRY STANDARDS TO CREATE TEMPLATES (J2012)

- Approximately 10,000 Diagnostic Trouble Codes (DTCs)
- Example: *Turbocharger/Supercharger Bypass Valve "A" Control Circuit Out of Range Low* Written in the Form -
  - <Assembly Name> <Standard Failure Type>
  - or <Function Name> <Standard Failure Type>
  - or <Assembly Name> <Circuit Name> <Standard Failure Type>
  - or <Assembly Name> <Signal Name> <Standard Failure Type>
  - Where Assembly Name := <Assembly Name> | <Assembly Name> <SubAssembly Name>

- From which we extract –
  - Appx 900 Standard Assemblies
  - Appx 2500 Circuits
  - Appx 1500 Signals
  - Appx 130 Standard Failure Types (Categorized by Assembly / Interface Type))

- Example: *Turbocharger/Supercharger Bypass Valve "A" Control Circuit Out of Range Low*
  - Assembly Name: *Turbocharger/Supercharger*
  - Sub-Assembly Name: *Bypass Valve "A"*
  - Circuit: *Control Circuit*
  - Standard Failure Type: *Out of Range Low*

USING INDUSTRY STANDARDS TO CREATE TEMPLATES (OTHERS)

J1939 Standard Signals for Commercial Vehicles

- Appx 10,000 Standard Periodic Commercial Parameters
- Example*: Engine Turbocharger Wastegate Actuator 1 Command*
- Appx 150 Standard Functions
- Example*: Engine Emission Aftertreatment System*

J1979: Standard Signals for Passenger Vehicles

- Appx 1,000 Periodic Automotive Parameters
- Example*: Turbocharger Compressor Inlet Pressure Sensor A*
- Appx 100 Requestable Parameters
- Example*: Misfire Cylinder 1 Data*

USING INDUSTRY STANDARDS TO CREATE TEMPLATES (OTHERS)

J1930 Naming Standards

- Appx 150 Standard System Names
- Example*: Exhaust Gas Re-circulation Subsystem*
- Appx 150 Standard ECU Names
- Example*: Exhaust Gas Re-circulation Control Module*
- Appx 800 Standard Terms
- Example*: Suspension - Steer Axle*

- Naming Grammar Rules

4.1 Naming Objects

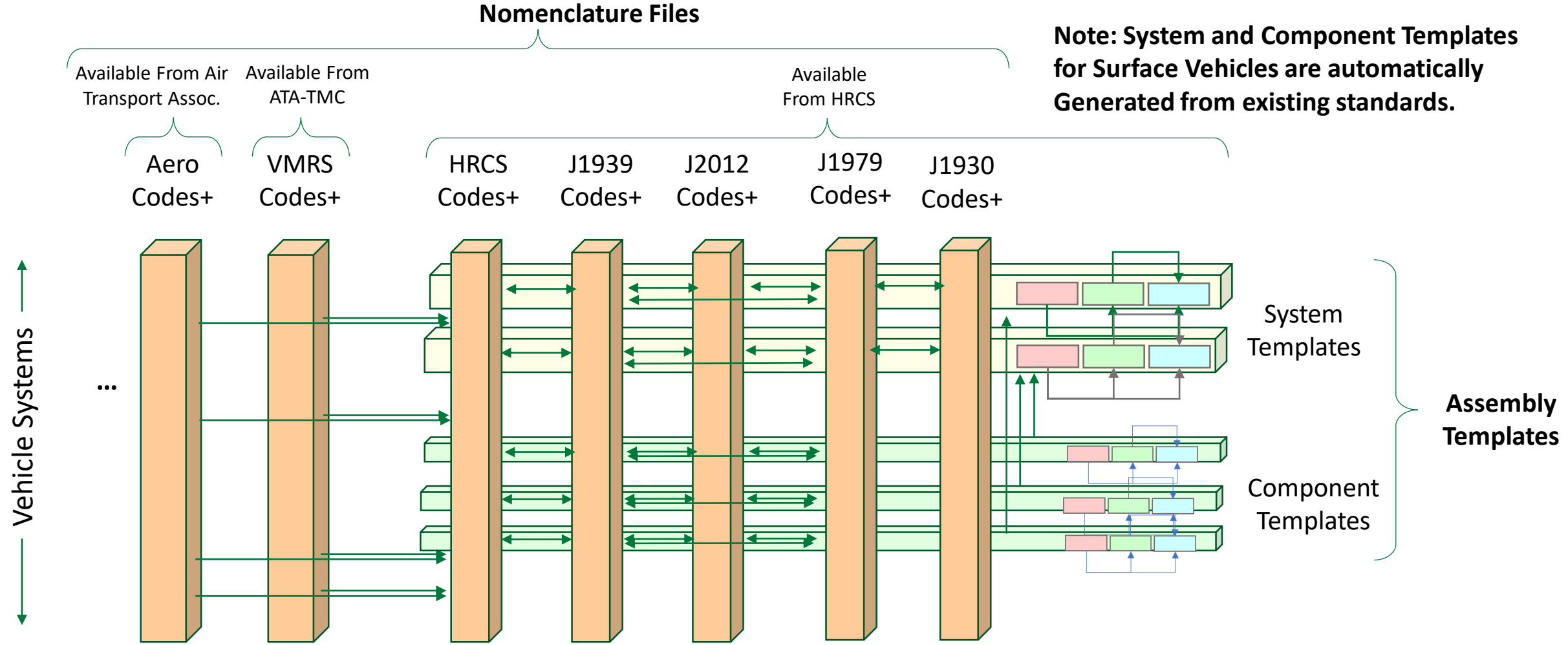
When building names, select the most descriptive base word from the Glossary of Terms (see SAE J1930DA, Appendix D). Add modifiers as necessary or as desirable within the context, in the order of most significance to least significance. The most significant word will be the base word, which denotes the basic function of the object. The most significant modifier will be adjacent to the base word, the second most significant will be next to that modifier, and so on until the least significant modifier is added. For the sake of future clarity, an additional modifier can be added to a name at any time, even if there is no present conflict with another object name. Example 1 illustrates how modifiers can be added to build the name, "Instrumentation Engine Coolant Temperature Sensor."

When naming an object, it is tempting to choose the first modifiers according to the initial purpose for which the object was designed, but this will not always result in the name which is most helpful in the long run to a service technician. The information a technician needs is most often supplied by a term which describes a functional attribute, not purpose.

MODIFIERS				BASE WORD	
What is its purpose?	**Where is it?**	**Which Temp?**	**What does it sense?**	**What is it?**	
				Sensor	Most generic
			Temperature	Sensor	
		Coolant	Temperature	Sensor	
	Engine	Coolant	Temperature	Sensor	Most specific
Instrumentation	Engine	Coolant	Temperature	Sensor	
Least <---------- SIGNIFICANCE --- ----------> Most					

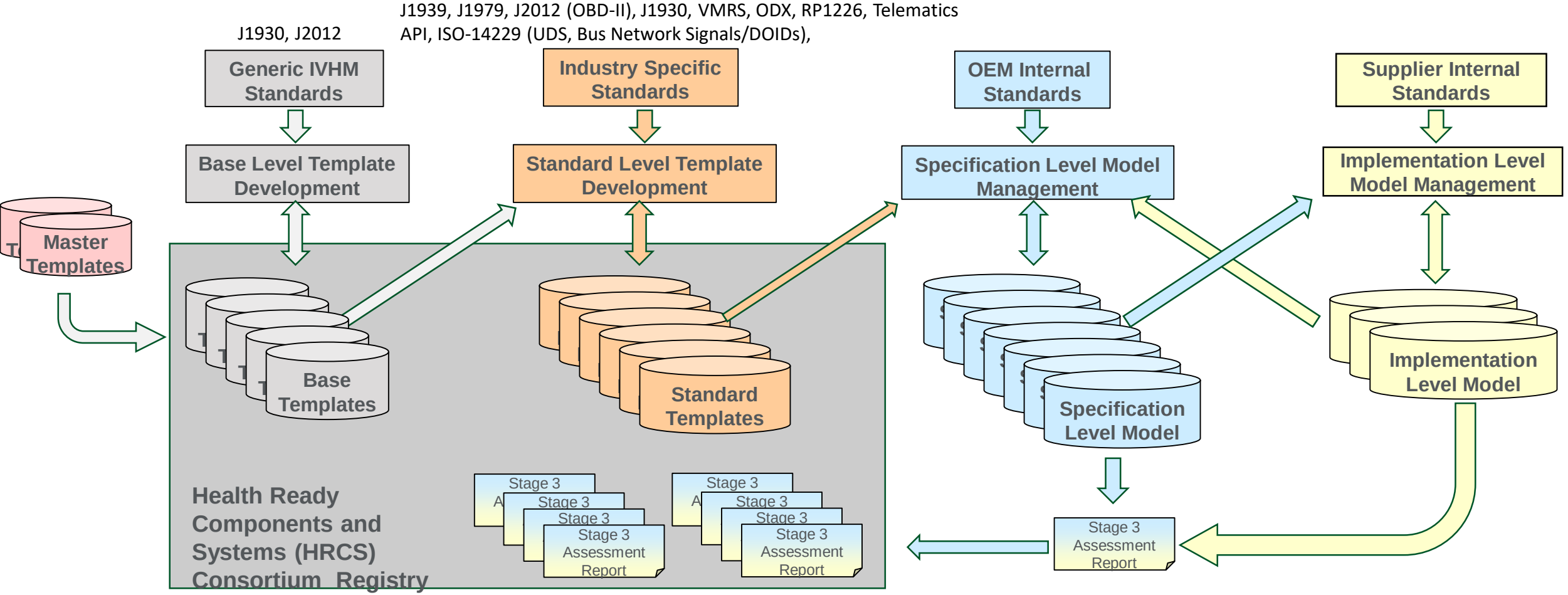
Example 1 - Modifier usage example

TEMPLATE DEVELOPMENT APPROACH



Note: System and Component Templates for Surface Vehicles are automatically Generated from existing standards.

Overall JA6268 Template and Datasheet Development Process



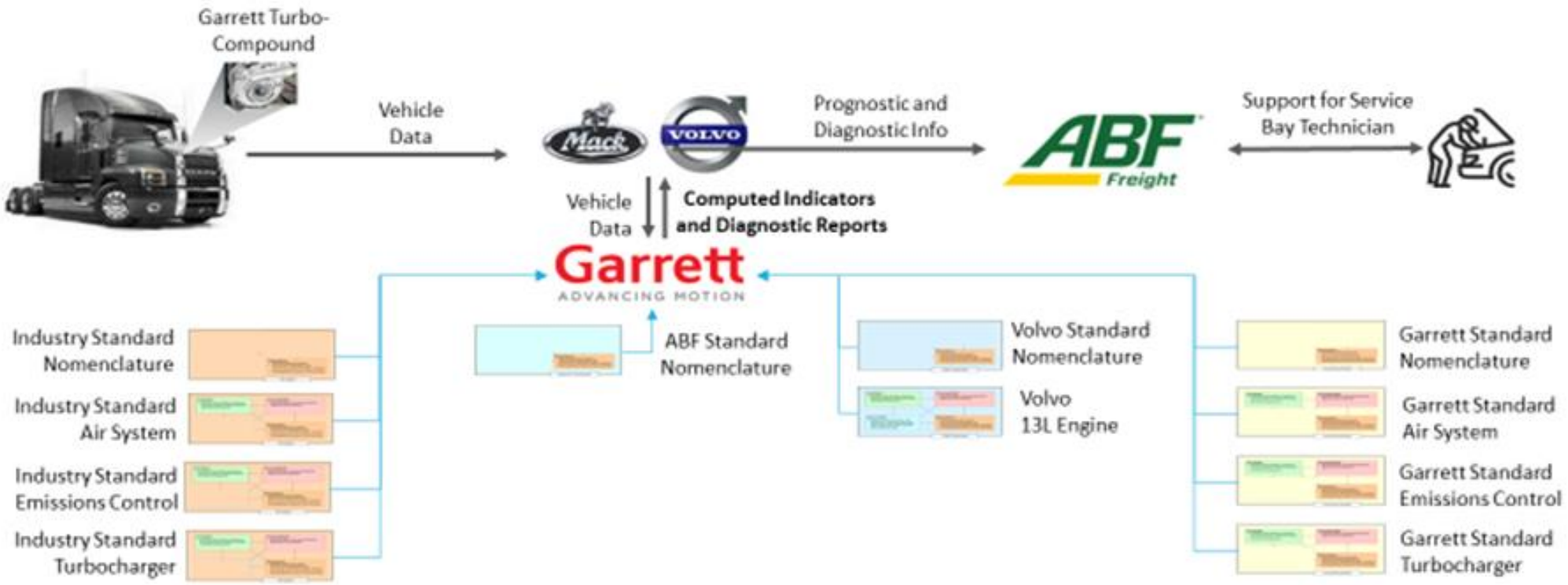
ABF- MACK / VOLVO – GARRETT PILOT PROGRAM

ATA TMC JA6268 MACK/GARRETT/ABF PILOT OVERVIEW

- Overview:
  - Use JA6268 templates for specification and message routing data of engine Air System
  - ~300 Mack vehicles w/ Garrett Turbochargers managed by ABF.
- Objectives and Success Metrics:
  - Use of JA6268 reduces the effort to configure the communications, invoke the algorithms and receive the results
    - **Metric 1: Comparison of Effort using JA6268 compared to similar activities performed without**
    - **Metric 2: Diagnostic Accuracy**
  - Use of JA6268 allows Mack / ABF to implement aspects of IVHM that have not been previously feasible / affordable
    - **Metric 3: Value of New Capabilities**

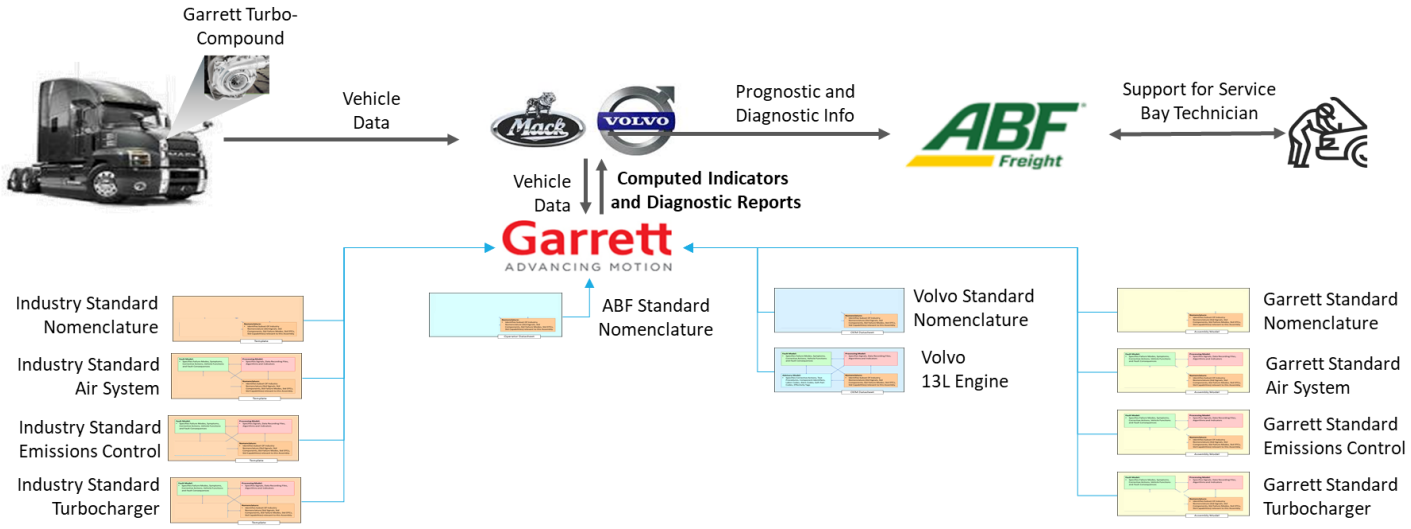
Prove that JA6268 template reduce the effort to develop High Accuracy IVHM Functionality

ATA TMC JA6268 MACK/GARRETT/ABF PILOT OVERVIEW



The Program Uses HRCS Provided Templates and Datasheets to Compute JA6268 Compatible Indicators and Diagnostic Reports

MACK/GARRETT/ABF PILOT PRELIMARY RESULTS



Metric 1: Comparison of efforts using JA6268 compared to similar activities performed without

Preliminary results: up to 50% effort reduction in building diagnostic functions and health indicators using JA6268 template for Garrett and Volvo/Mack

Next steps: consolidate preliminary results and measure effort for ABF

Metric 2: Diagnostic accuracy

Preliminary results: adding Health Indicators from supplier reduced diagnostic ambiguity by 50% for Volvo. This results in substantial reduction in troubleshooting time and NTF rates.

Next steps: consolidate preliminary results and measure accuracy adding ABF information

Metric 3: value of new capabilities

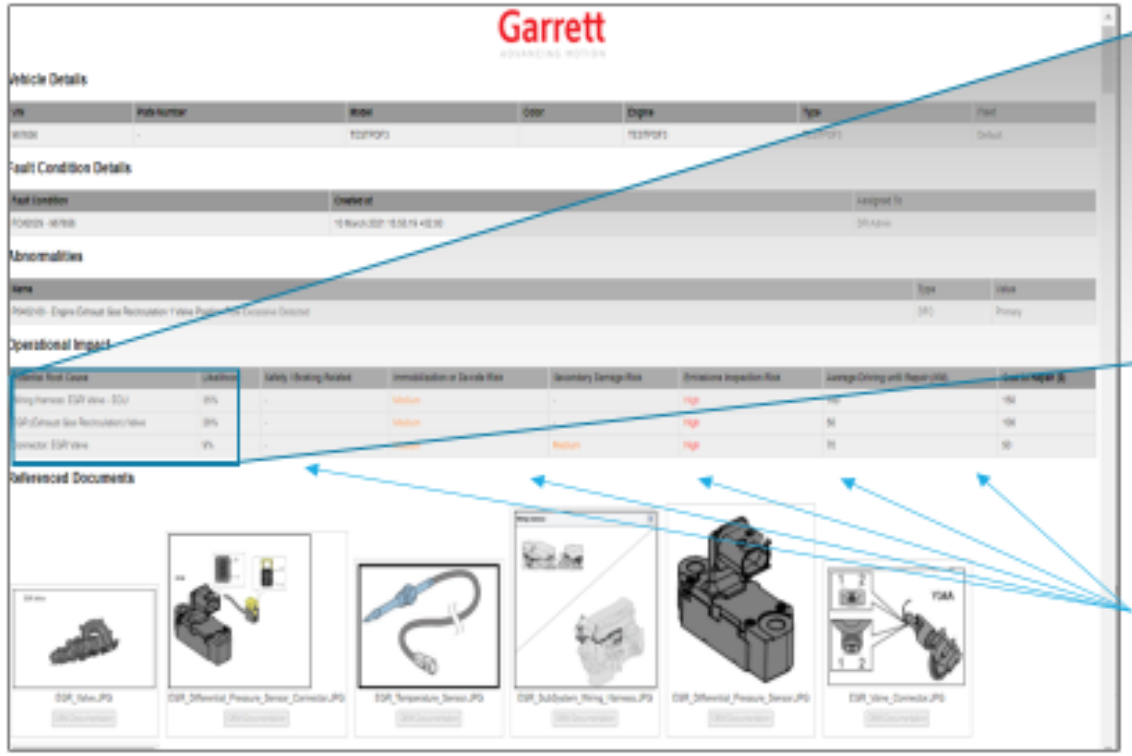
Not measured to date

Next steps: evaluate results for Mack/Volvo, Garrett and ABF

Program has demonstrated substantial improvement in time to implement the IVHM functions and the resulting diagnostic accuracy

DIAGNOSTIC RESULTS W/ JA6268 DATASHEET

Root Cause Diagnosis Using Standard JA6268 Templates



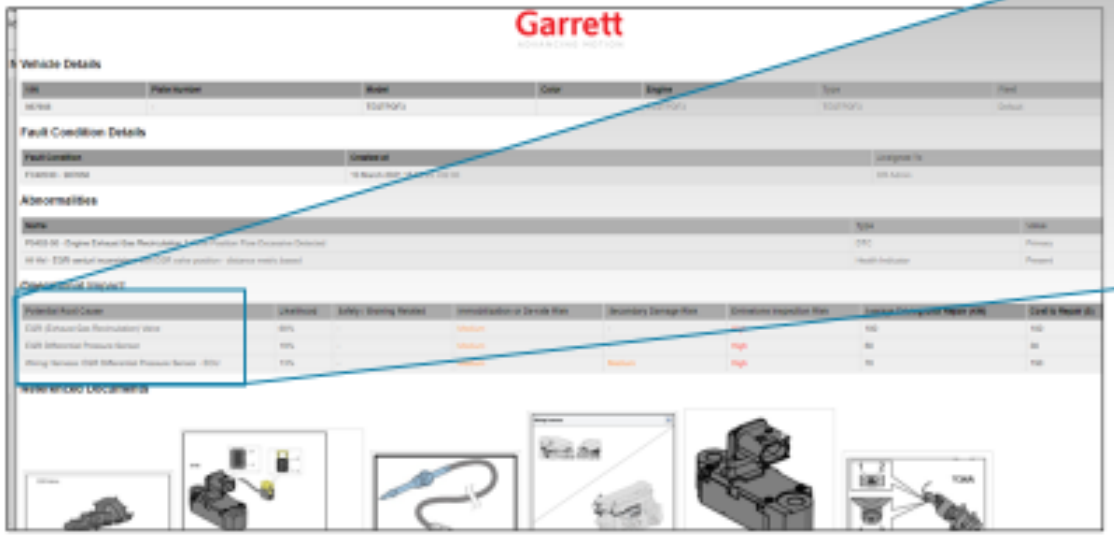
Potential Root Cause	Likelihood
Wiring Harness: EGR Valve ECU	35%
EGR (exhaust Gas Recirculation) Valve	28%
Connector: EGR Valve	9%

Assessment of Safety Impact, Immobilization, Risk of Secondary Damage and Cost of Repair Data is Provided to Assist in Routing and Scheduling Decisions

JA6268 enabled to create advanced diagnostic information for air path system

DIAGNOSTIC RESULTS WITH SUPPLIER HEALTHINDICATORS

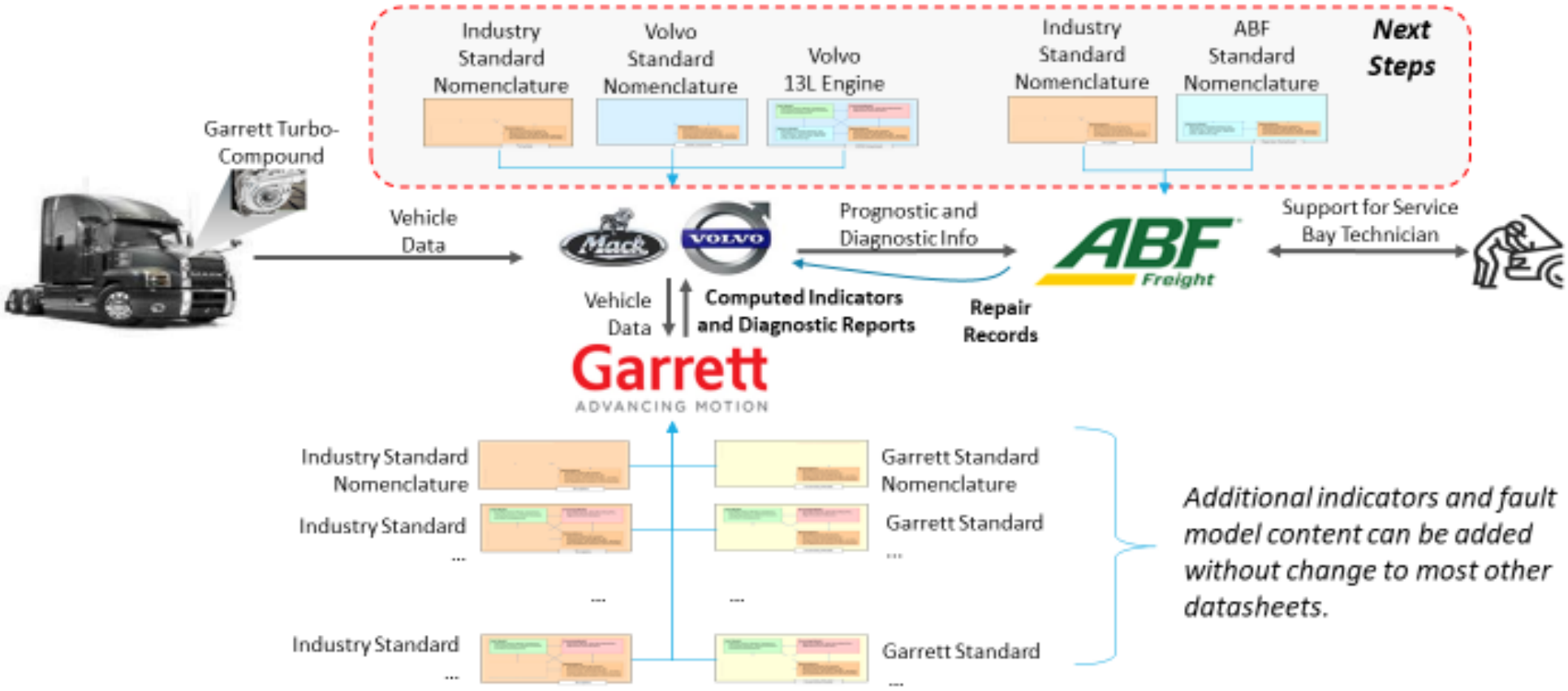
Root Cause Diagnosis Using Standard JA6268 Templates and supplier health indicators



Potential Root Cause	Likelihood
EGR (exhaust Gas Recirculation) Valve	66%
EGR Differential pressure sensor	19%
Wiring Harness: EGR Diff. Pressure sensor - ECU	9%

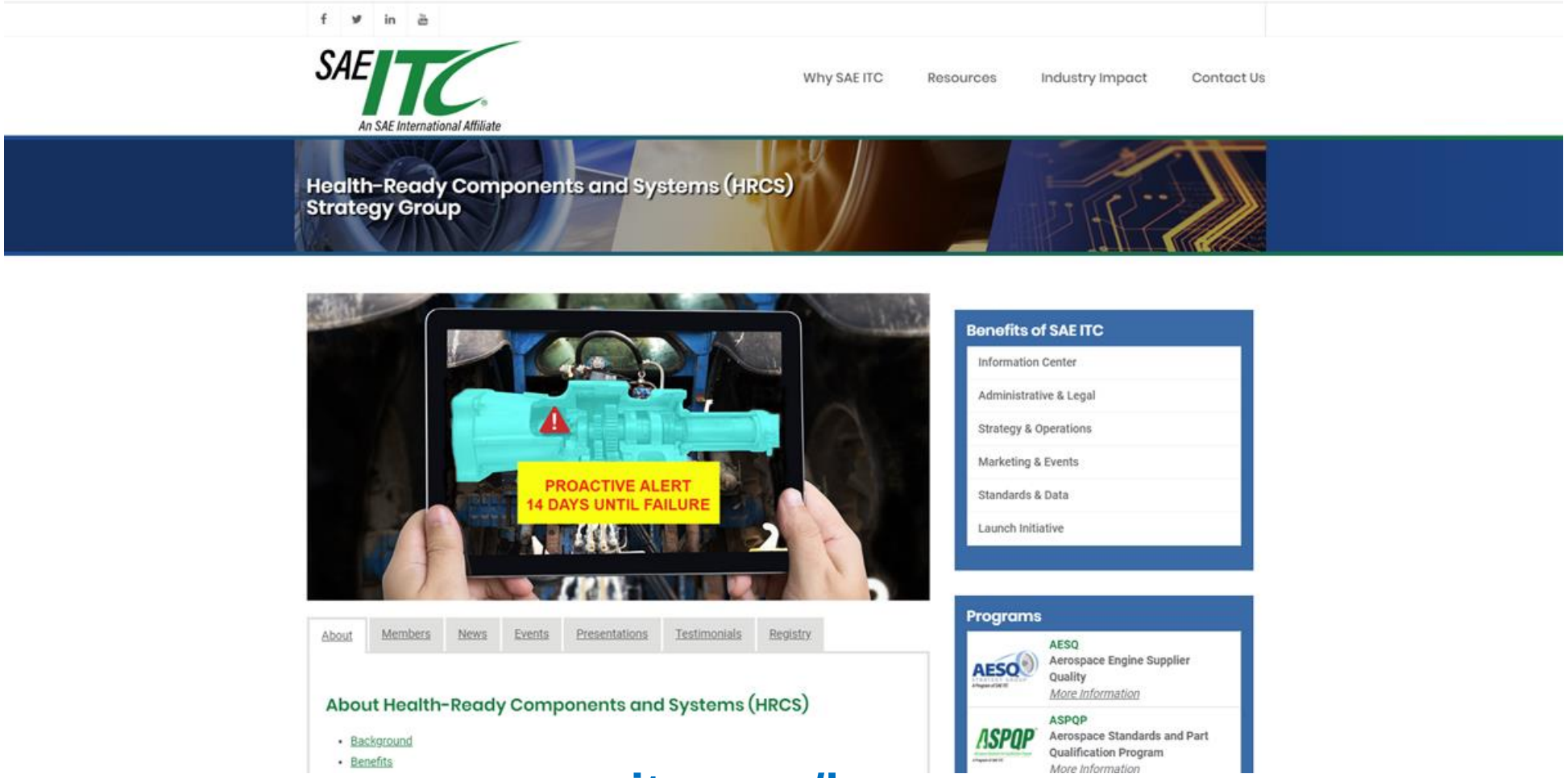
JA6268 Supports Development of Additional Indicators that Improve Diagnostic Accuracy and Enable Predictive Maintenance

ATA TMC JA6268 MACK/GARRETT/ABF – NEXT STEPS



Next Steps: Deploy JA6268 Compliant Functions to Volvo/Mack and ABF and Extend the Scope of the Supported Systems.

HEALTH-READY COMPONENTS AND SYSTEMS



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ATA/TMC - HRCS CONSORTIUM

Questions?

FOUNDATIONAL DOCUMENT: SAE JA6268

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.

SAE VEHICLE MAINTENANCE/IVHM CAPABILITY

(VEHICLE LEVEL)

(SOURCE: SAE 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	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.	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	Introduction of microprocessor-based controls & OBD 1980-1995
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	Introduction of GM OnStar telematic services 1996-2014 (OBD II)
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	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 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	Necessary 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.	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	Long-range vision

HEALTH-READY COMPONENTS & SYSTEMS CONSORTIUM

- Based on SAE JA6268™ – “Design and Run-Time Information Exchange for Health-Ready Components”
- Consortia Background
  - HRCS fosters improvements in reliability, performance, and safety by applying IVHM concepts
  - IVHM is a critical and enabling technology for autonomous vehicles
  - HRCS is multi-sector, high overlap across commercial vehicle, automotive, aerospace, defense, and others
- Positioning – HRCS membership shapes the program which in turn shapes the industry
  - Fleet Operators – moving away from diagnosis and repair to predictive analytics, thereby reducing downtime and improving efficiency, and standardized communications methods
  - OEMS – higher reliability, customer satisfaction, & safety; reduced warranty costs, standardized protocols
  - Part Suppliers – feedback on performance of their parts in the field, standardized protocols, and better visibility to customers
- Why now? – Drive use of a common standard before the market fragments into costly proprietary solutions

HRCS CONSORTIUM GOALS

- Ensure **interoperable** instead of limited & costly proprietary solutions
- Protection of operating in a legal, pre-competitive environment as a 501(c)(6) organization
- Build on existing standards and documents (e.g.: **OBD codes** in automotive**, SAE J1939, J1979, & J2012, ATA codes** in aviation, **VMRS codes** in trucking, and others) that can be augmented to better support health-ready components
- Agreed upon **actions to put SAE JA6268™ into practice** by going down a level from the recommended practices captured in JA6268
- Establish a foundation and methodology to tackle the numerous components, systems and subsystems with a common approach across Aero, Auto, Trucking

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WHAT IS A HEALTH-READY COMPONENT?

- Health-ready components monitor their own health condition or enable other controllers to perform that function. For example, an automobile starter might monitor parameters such as these for anomalous conditions:
    1.) Cranking speed
    2.) Current draw/voltage drop
    3.) Bendix engagement time
    4.) Environmental conditions
    5.) Vibration
- Instead of a “**Check Engine**” light, a prognostic algorithm could calculate Remaining Useful Life (RUL) and inform the driver to go in for service within two weeks.
- Highly accurate prognostics reduce both diagnostic time and repair costs.
- Information sharing should be ***machine-readable*** and standardized for interoperability
- ***This is the key to unlocking the potential of Integrated Vehicle Health Management (IVHM)***