

A group of five diverse professionals standing on a large, light blue gear graphic. From left to right: a woman in a blue cap and overalls holding a hammer and a briefcase; a man in a grey suit and tie; a man in blue overalls with arms crossed; a man in a light blue shirt and khaki pants; and a man in a dark blue shirt and jeans holding a clipboard. The background is a dark blue grid of glowing dots.

TME20

ATA's Technology & Maintenance Council
ANNUAL MEETING
& Transportation Technology Exhibition

ADVANCING CAREERS
in MAINTENANCE MANAGEMENT

Georgia World Congress Center
Atlanta, Georgia | Feb. 24-27, 2020



Technology & Maintenance Council

... Turning Experience Into Practice

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Constructive Comments Are Always Appreciated!

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

Thank You for Your Cooperation!

Agenda

- SAE IVHM and the Health-Ready Components and Systems (HRCS) Consortium
 - Pete Grau
- A Supplier View of JA6268 and HRCS
 - Tim Felke
- Wrap-Up & Discussion
 - Pete Grau

IVHM AND THE HEALTH-READY COMPONENTS AND SYSTEMS (HRCS) CONSORTIUM

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2020 Technology & Maintenance Council Conference, Atlanta GA.



*Collaborative Innovation.
Trusted Implementation.*

FOUNDATIONAL DOCUMENT: SAE JA6268⁸



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/

SAE AUTONOMOUS VEHICLE IVHM CAPABILITY **(VEHICLE LEVEL)**

(sources: SAE J3016 & JA6268™)

Illustrating autonomous vehicle capability

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

SAE Level	Name	Narrative Definition	Execution of Steering and Acceleration/Deceleration	Monitoring of Driving Environment	Fallback Performance of Dynamic Driving Task	System Capability (Driving Modes)
Human driver monitors the driving environment						
0	No Automation	the full-time performance by the <i>human driver</i> of all aspects of the <i>dynamic driving task</i> , even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	Driver Assistance	the <i>driving mode</i> -specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the <i>human driver</i> perform all remaining aspects of the <i>dynamic driving task</i>	Human driver and system	Human driver	Human driver	Some driving modes
2	Partial Automation	the <i>driving mode</i> -specific execution by one or more driver assistance systems of both steering and acceleration/deceleration using information about the driving environment and with the expectation that the <i>human driver</i> perform all remaining aspects of the <i>dynamic driving task</i>	System	Human driver	Human driver	Some driving modes
Automated driving system ("system") monitors the driving environment						
3	Conditional Automation	the <i>driving mode</i> -specific performance by an <i>automated driving system</i> of all aspects of the <i>dynamic driving task</i> with the expectation that the <i>human driver</i> will respond appropriately to a <i>request to intervene</i>	System	System	Human driver	Some driving modes
4	High Automation	the <i>driving mode</i> -specific performance by an <i>automated driving system</i> of all aspects of the <i>dynamic driving task</i> , even if a <i>human driver</i> does not respond appropriately to a <i>request to intervene</i>	System	System	System	Some driving modes
5	Full Automation	the full-time performance by an <i>automated driving system</i> of all aspects of the <i>dynamic driving task</i> under all roadway and environmental conditions that can be managed by a <i>human driver</i>	System	System	System	All driving modes

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 gauges.	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

Diagnosis: Determine the root cause of a problem once a failure **HAS** occurred

Prognosis: Predict a potential failure **BEFORE** it occurs while component is still operating

HRCS FOCUS: *MOBILITY* (BUT CAN ALSO BE APPLIED TO FIXED-BASE EQUIPMENT)



Current Members:

Bell Aerospace

Global Strategic Solutions

General Motors

Garrett Motion

VHM Innovations

Volvo GTT (Group Trucks Technology)

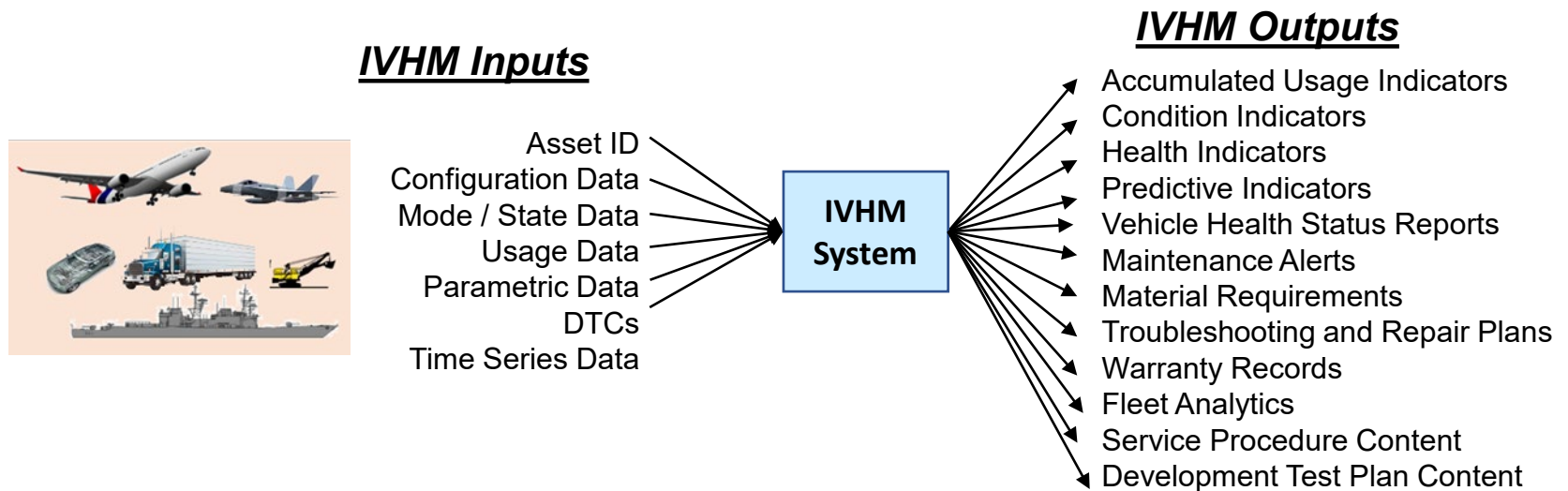
A SUPPLIER VIEW OF JA6268 AND THE HRCS CONSORTIUM

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2020 Technology & Maintenance Council Conference, Atlanta Georgia.

Integrated Vehicle Health Management (IVHM) Definition and Functionality

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



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

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

IVHM Value Proposition

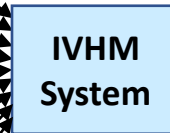
IVHM Costs

Build / Maintain IVHM Solution

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

Execute Maintenance Program

- Perform Fault Isolation Tasks
- Procure Replacement Hardware
- Perform Fault Preventative Actions
- Perform Corrective Actions



IVHM Benefits

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

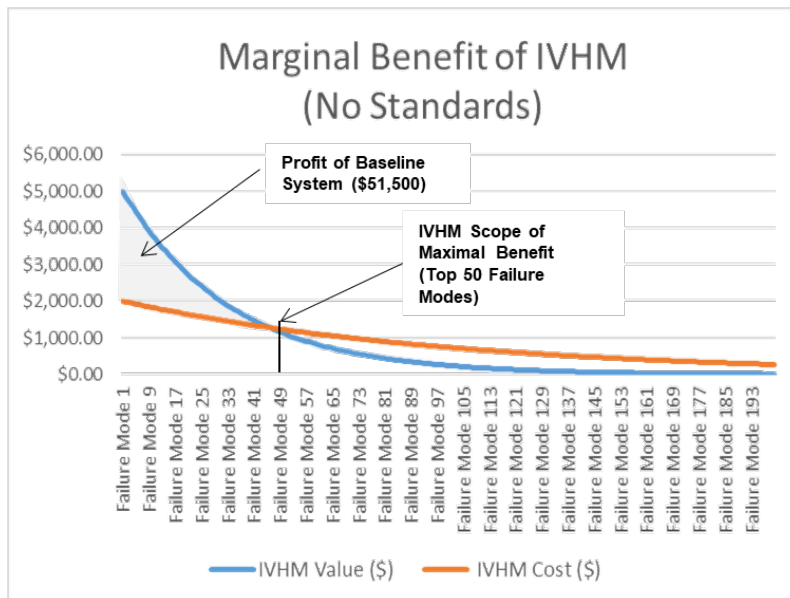
IVHM Design Problem Statement:

What is the best combination of IVHM functionality that maximizes its lifecycle value vs the costs of implementation?

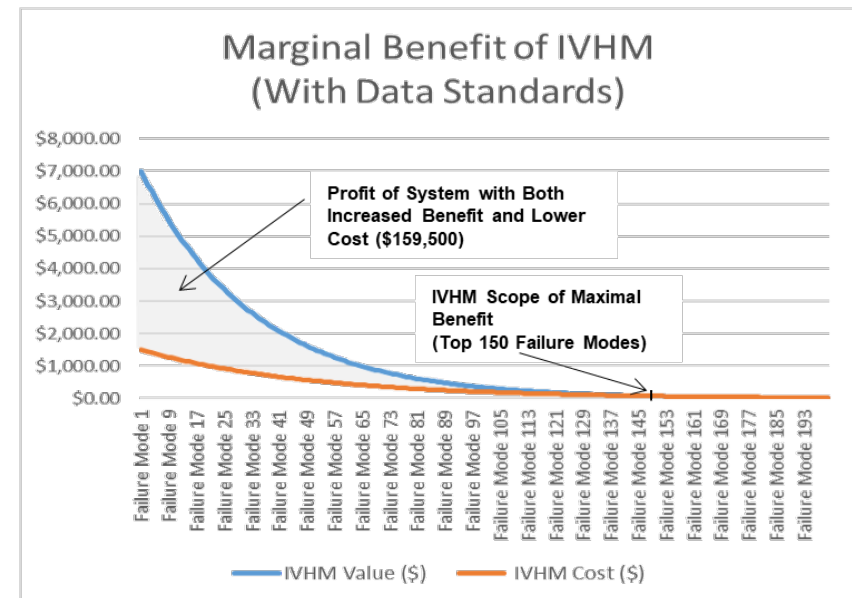
Increasing IVHM Value Through Data Standards

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

Current Practice (Typical)



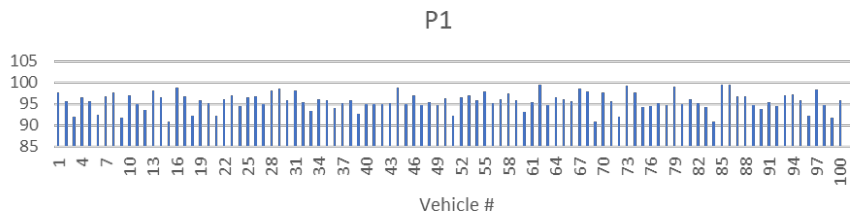
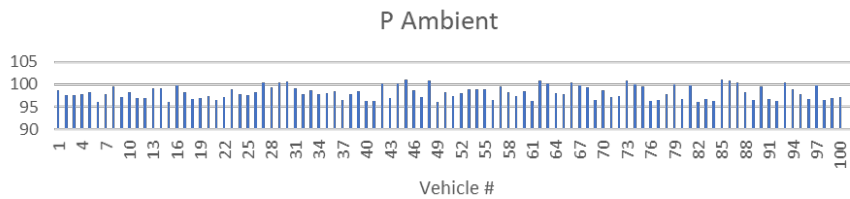
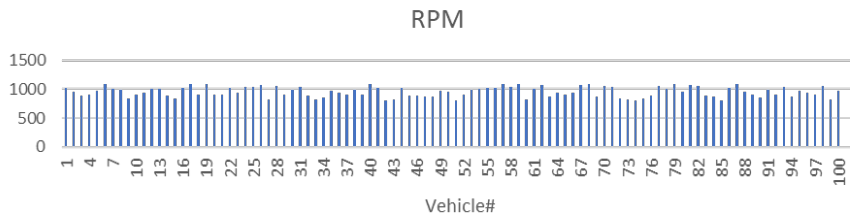
Future Practice



Much greater profit across the lifecycle can be achieved through use of standards

IVHM Implementation Challenge – Find the Degraded Parts

Can you find the bad parts using the available data?



Data is provided:

- Engine RPM
- Ambient Pressure
- Pressure Measured Downstream of Air Filter for 100 vehicles.

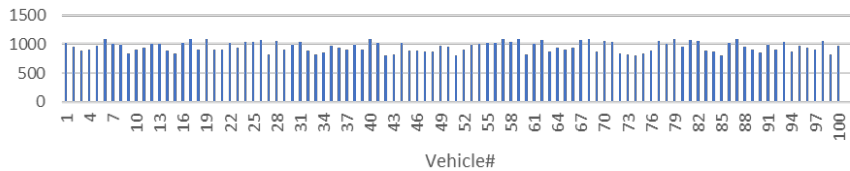
Find the ones for which the Air Filters are substantially clogged.

Can you see which ones are outliers?

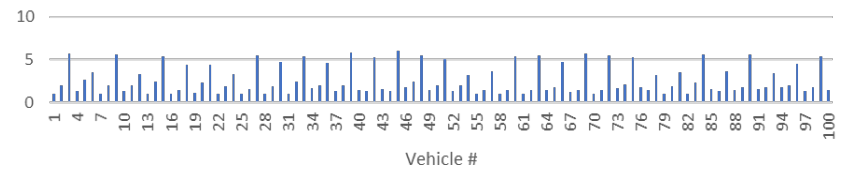
IVHM Implementation Challenge – Find the Degraded Parts

Can you find them now?

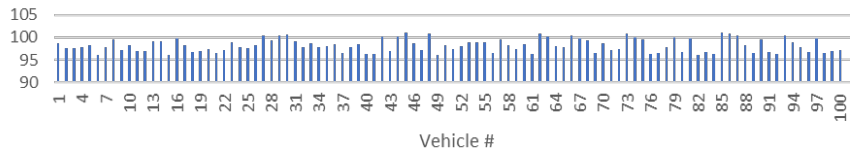
RPM



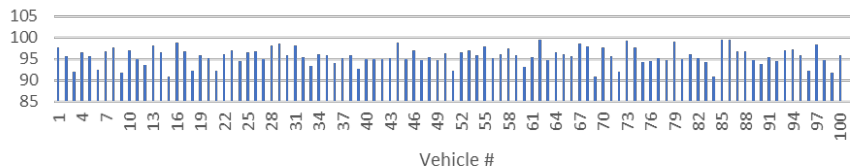
Delta P



P Ambient



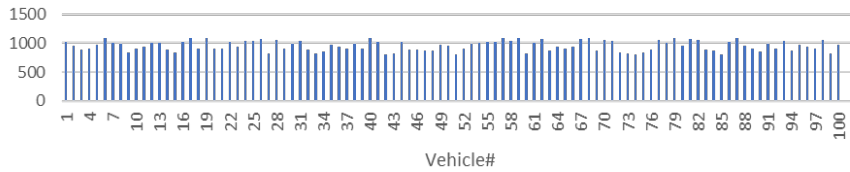
P1



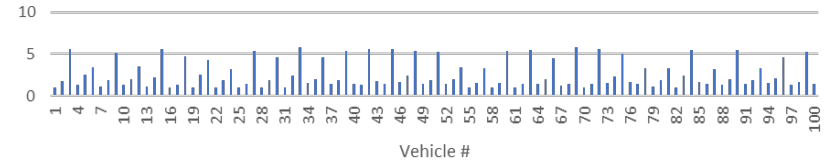
IVHM Implementation Challenge – Find the Degraded Parts

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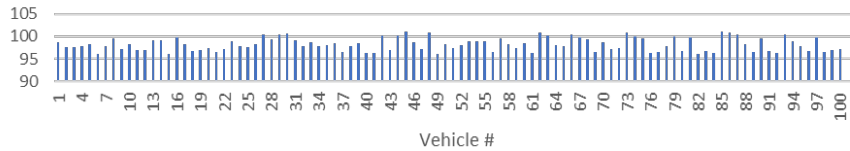
RPM



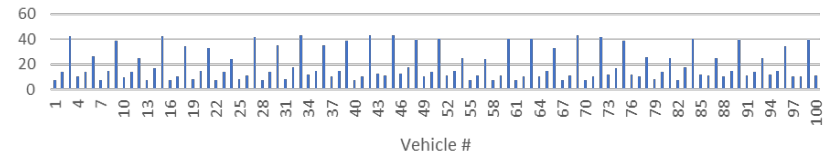
Delta P



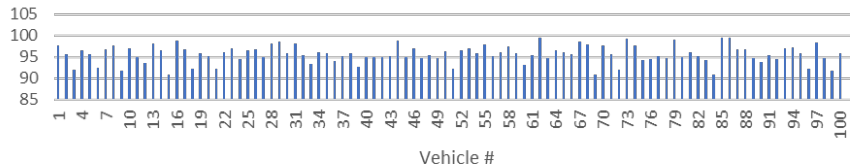
P Ambient



Air Flow



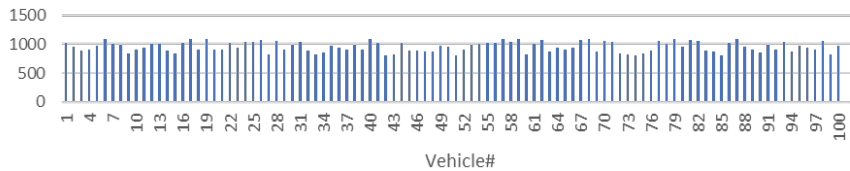
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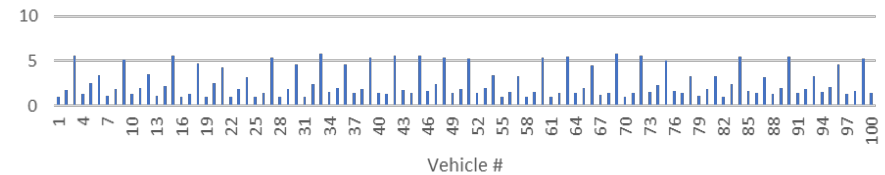
IVHM Implementation Challenge – Find the Degraded Parts

Can you find them now?

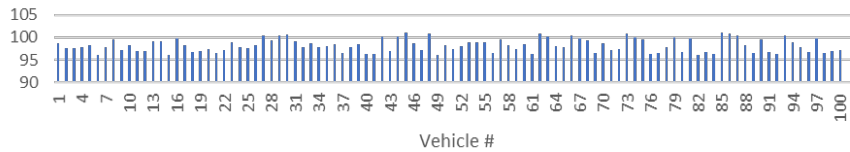
RPM



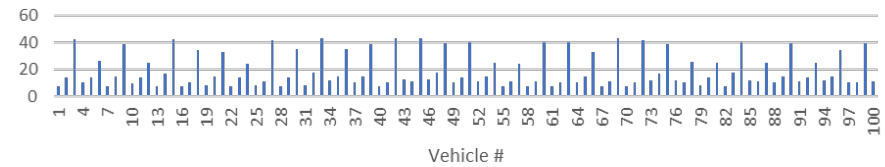
Delta P



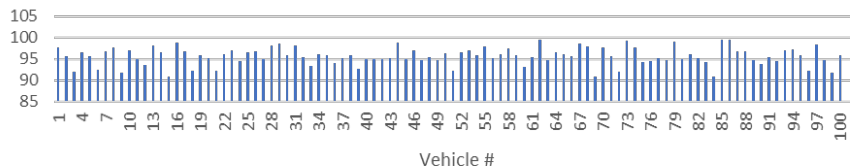
P Ambient



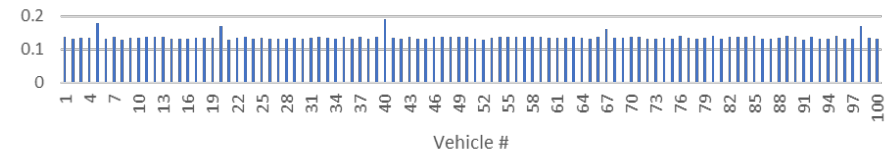
Air Flow



P1

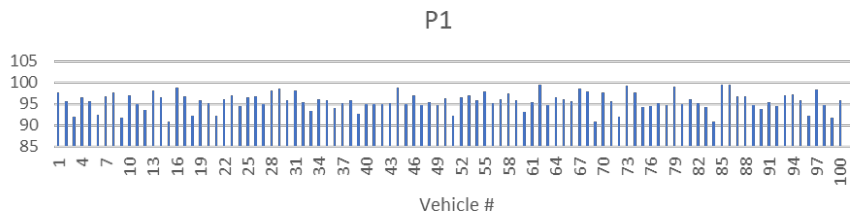
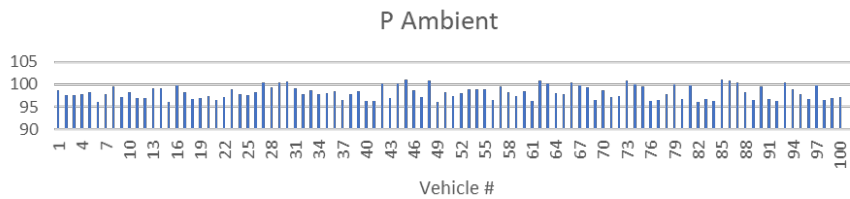
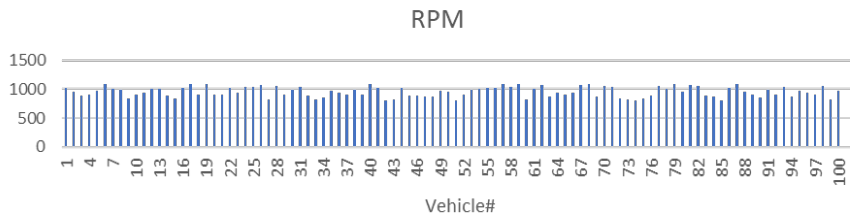


Resistance = Delta P / Air Flow



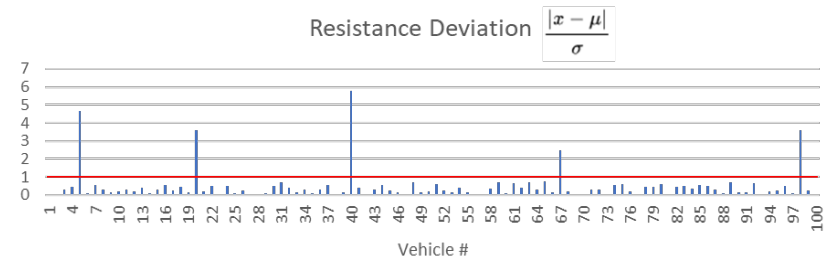
IVHM Implementation Challenge – Find the Degraded Parts

Can you find them now?



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

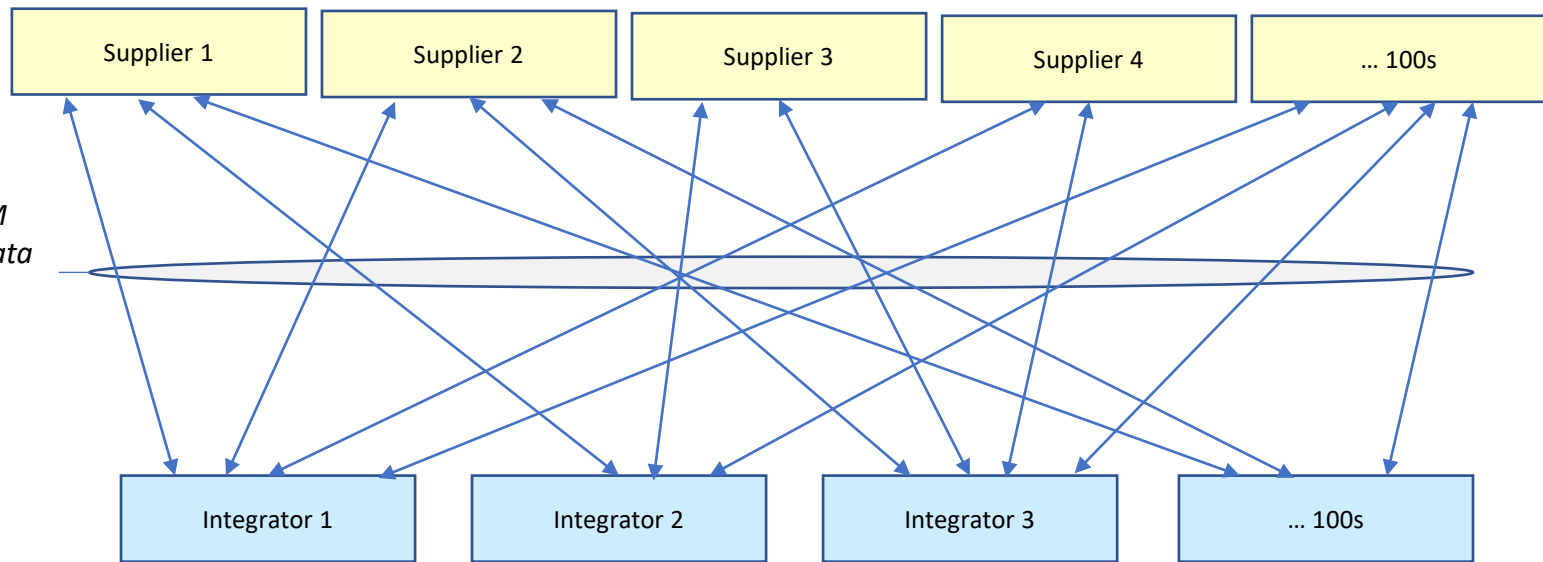
Adding system knowledge prior to Machine Learning greatly improves accuracy.



Component / System expertise can greatly improve the value of IVHM systems while reducing their cost.

JA6268 and HRCS Primary Use Case

Each supplier must work with dozens of Integrators



Exchange of IVHM Related Design Data and Equipment Status Data

Each Integrator must work with hundreds of Suppliers.

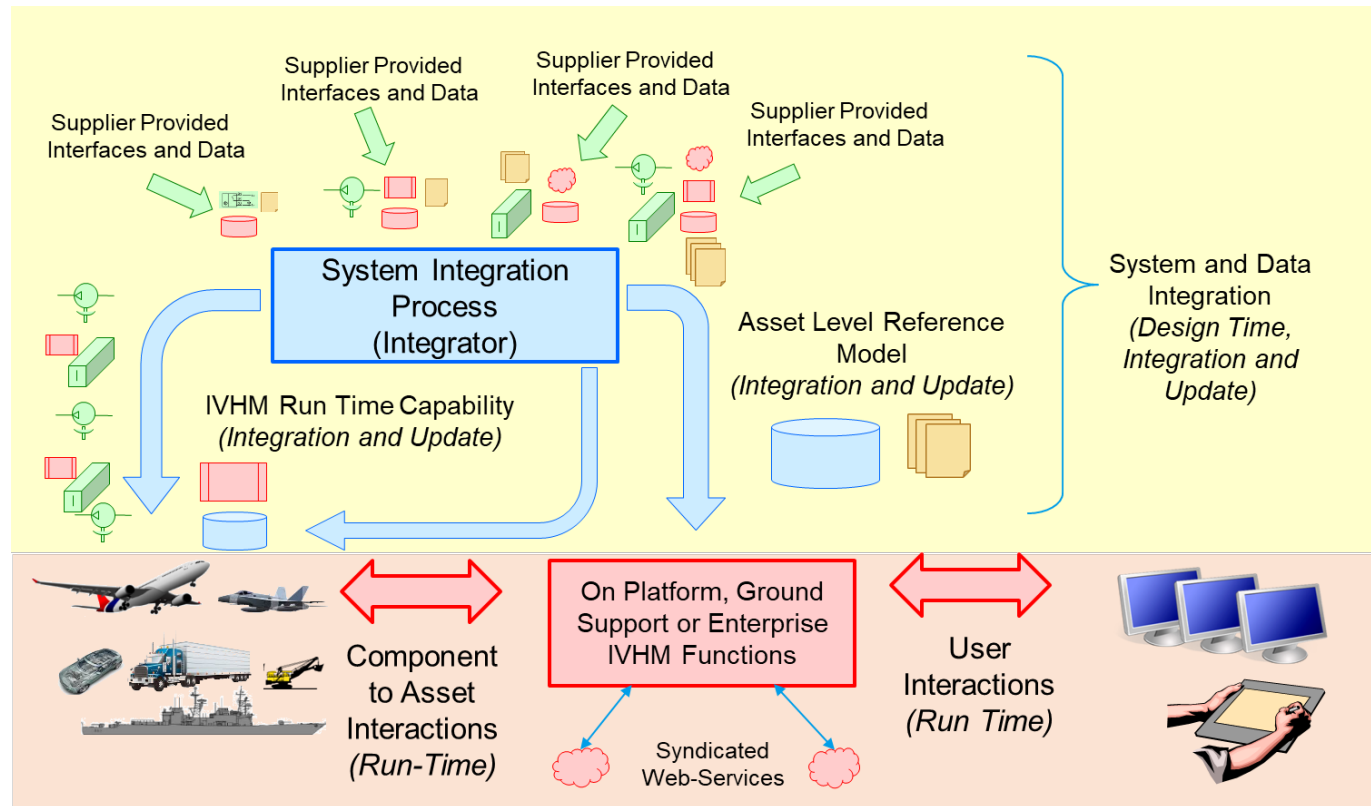
- Suppliers are a critical source of knowledge needed to implement IVHM for the equipment they provide.
- JA6268 was created to simplify the exchange of IVHM related data between Suppliers and Integrators
 - Standardized Exchange of Data from **Supplier to Integrator**: Allows Integrators to build Asset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

JA6268 Improves IVHM Related Communications

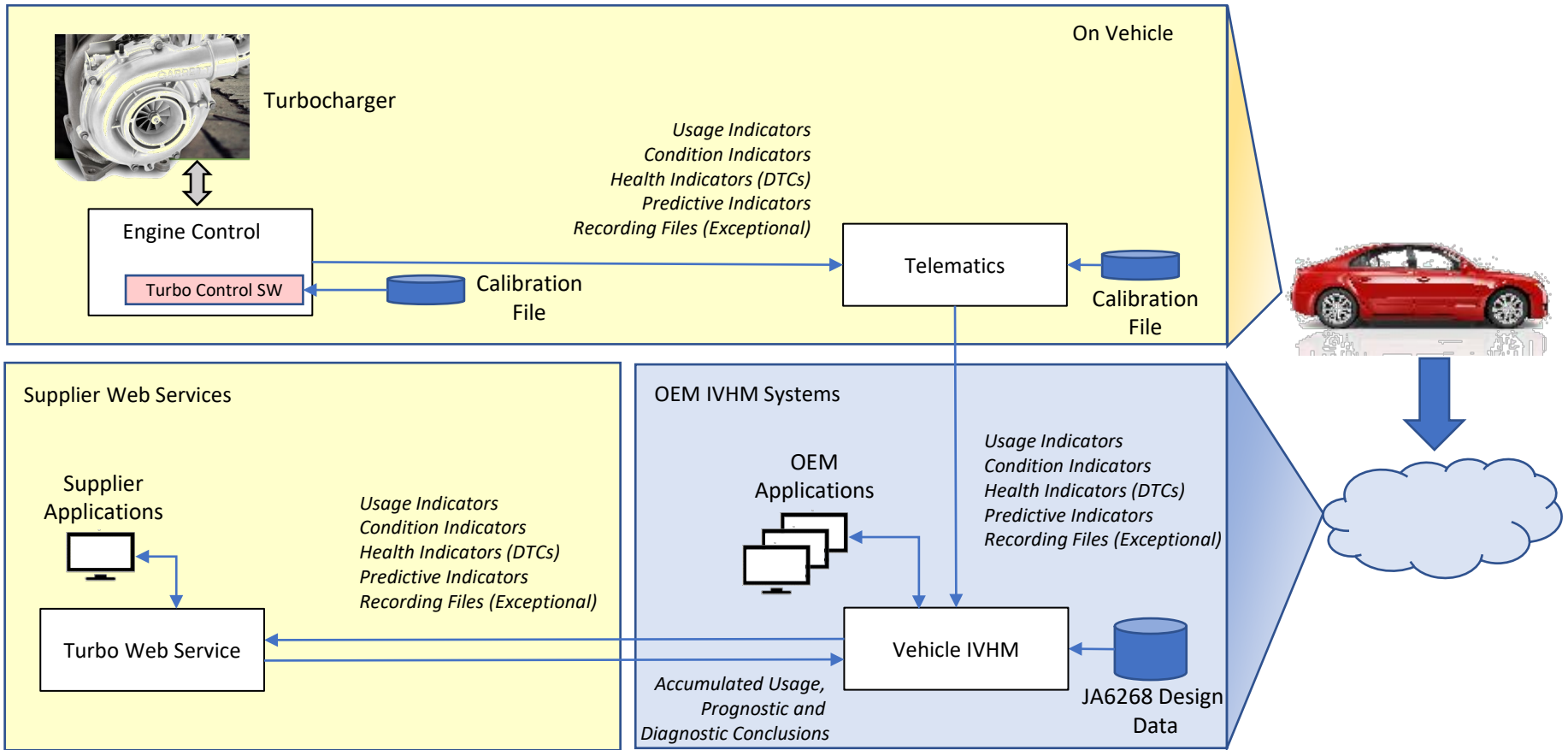
JA6268 is a Joint Aerospace and Automotive Recommended Practice Aimed at Reducing the Cost and Increasing the Value of IVHM Systems by Improving Communication Between Suppliers, Integrators and Operators.

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

Increase Value by providing standard interfaces to IVHM results to support additional use cases (Route Planning, Maintenance Planning, Material Planning, Asset Value Retention, etc.)



Example Application of JA6268 for Turbocharger



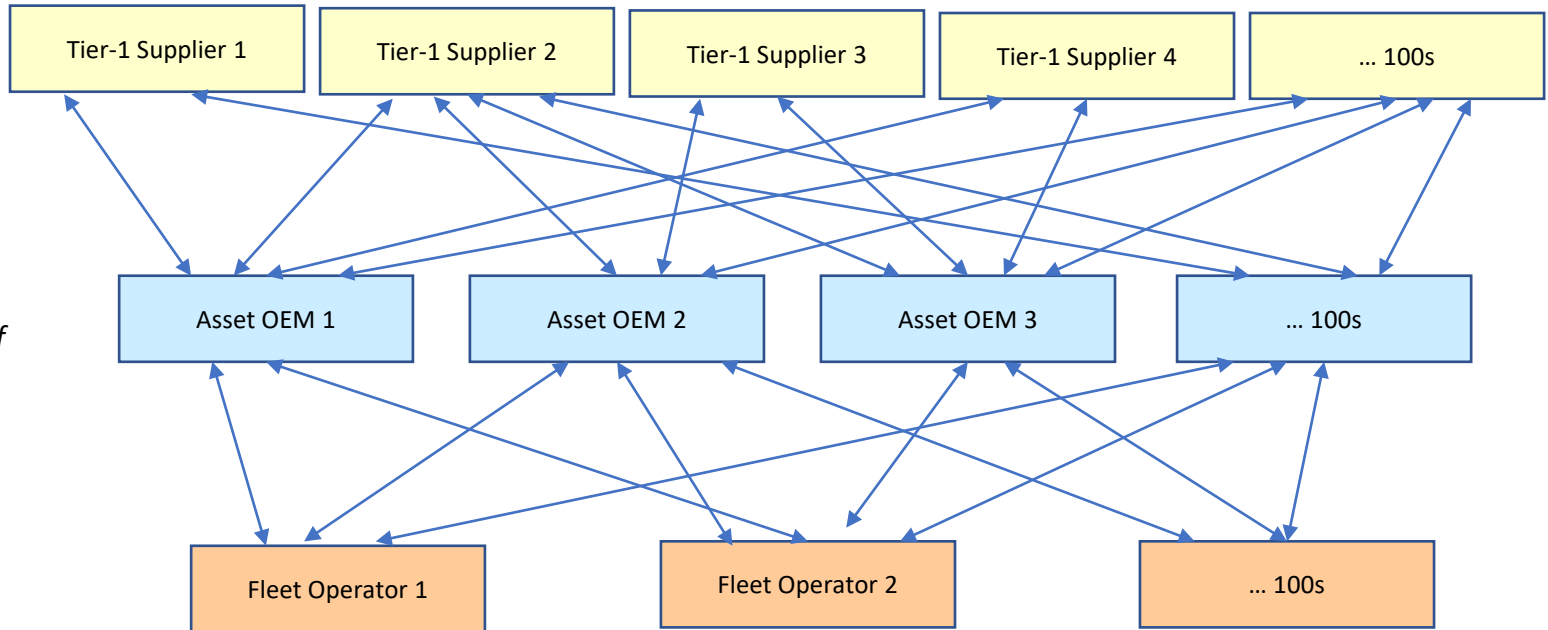
JA6268 is used to standardize run-time messages, web service APIs and design time data submittals

JA6268 and HRCS Benefit to Commercial Trucking

Each supplier must work with dozens of Integrators

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

Each Operator must work with dozens of Integrators



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

HRCS Accelerates the Adoption of JA6268

- The Health Ready Components and Systems (HRCS) Consortium was created in late 2019 to assist suppliers, integrators and operators in the implementation of JA6268.
- Help **Suppliers** use JA6268 to standardize IVHM design data submittals and to create compliant web services.
- Help **Integrators** utilize supplier design data and web services to provide more valuable prognostics, diagnostics, maintenance procedures and support services.
- Help **Operators** utilize design data to integrate web services into fleet operation and maintenance planning/execution systems.

Benefits to Component / System Suppliers

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

Benefits to Integrators

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

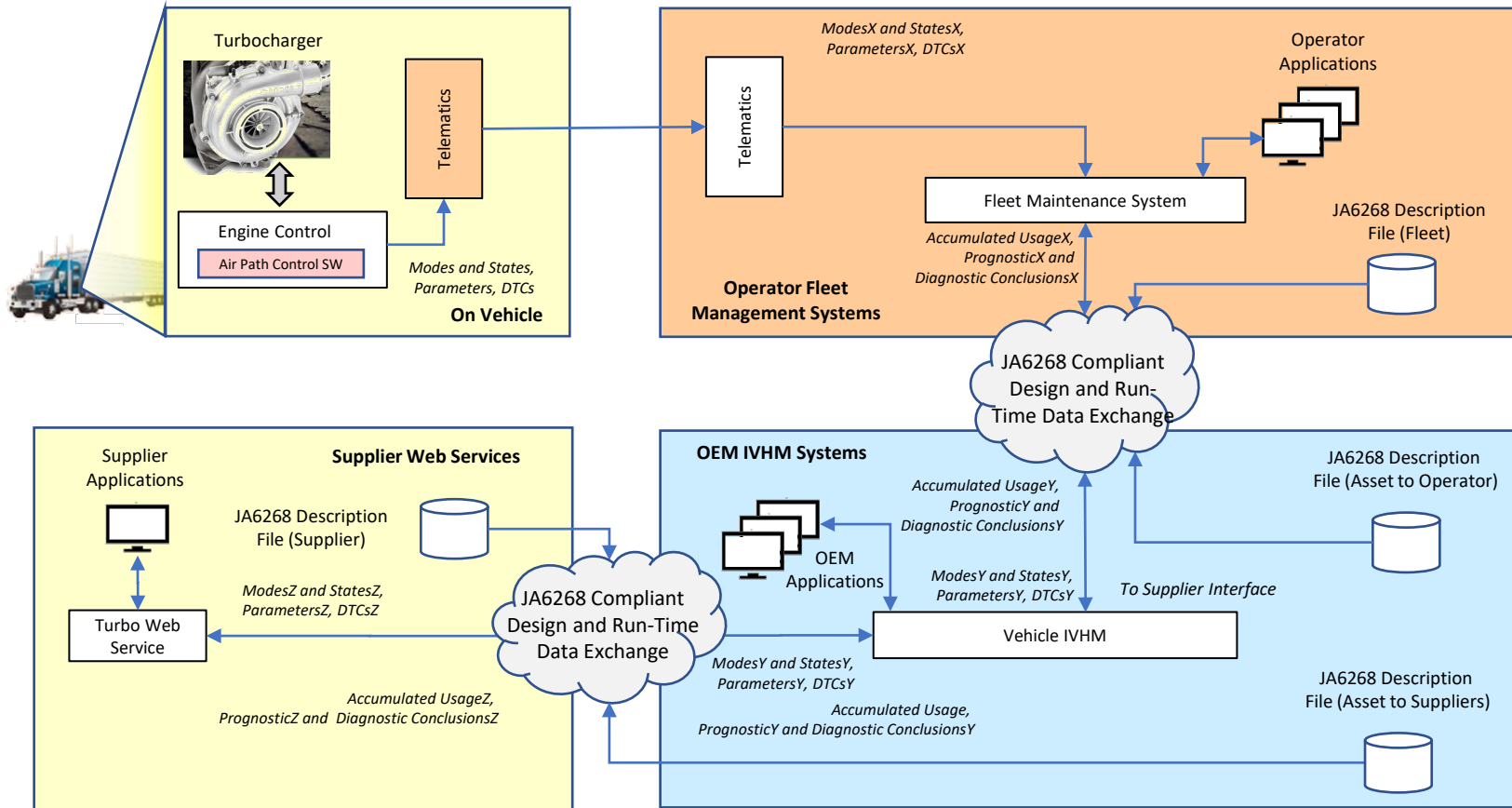
Benefits to Fleet Operators

- HRCS helps operators utilize design data to integrate web services into fleet operation and maintenance planning/execution systems.
- Allows operators to implement common IVHM functionality and content across all equipment.
 - Provides users with single process, look and feel for all functions across all types of equipment:
 - Tractors
 - Trailers
 - Major Subsystems
 - HVAC, Engine, Transmission, Brakes, After Treatment, Infotainment, etc.
 - Telematic Systems
- Standard interfaces to compliant web-services simplifies the integration of IVHM functions and content into operator applications.

JA6268 / HRCS Status and Plans

- JA6268 was published by SAE in April 2018.
 - Industry has been highly supportive of JA6268 objectives and methodology.
 - Industry recognizes that JA6268 does not provide all details needed to implement the method.
- HRCS Consortium was established in December 2019 to assist in deployment in JA6268.
 - Members of consortium are working together to specify additional details of data submittals and run-time interfaces.
- Proposals for several pilot programs are being evaluated to exercise all aspects of the practice.
 - Ideal pilot program will include Supplier, Vehicle OEM and Fleet Operators.
 - Commercial Trucking would be a very attractive candidate for pilot.
 - Intent is that pilot program would be substantially completed with 1 year of agreement to proceed.

Commercial Trucking – Proposed Pilot Program



Pilot will demonstrate how JA6268 and HRCS support the integration of IVHM Data and Functionality between Participants

HEALTH-READY COMPONENTS & SYSTEMS CONSORTIUM

Ready Components & Systems (HRCS)

Consortia Background

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

Positioning – Voting membership shapes the program – shapes industry

- **OEMS** – higher reliability, customer satisfaction, & safety; reduced warranty costs, standardized protocols
- **Fleet Operators** – moving away from diagnosis and repair to predictive analytics, reduced downtime, standardized protocols and interoperability between tractor and trailer
- **Part Suppliers** – obtain performance data feedback, standardized protocols, and visibility to customers

Why now? Technologically feasible, drive use of standards *before* market fragments

WHY JOIN THESE EFFORTS IN THE HRCS CONSORTIUM?

in THESE Efforts in the HRCS SG?

Ensure **interoperability** instead of proprietary solutions

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

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

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

Subcommittees tackle terminology/lexicon/vocabulary in important industry domains

Health-Ready Components and Systems (HRCS) Strategy Group



[Health Ready Components & Systems \(HRCS\) Charter](#)

Benefits of SAE ITC

- Administrative & Legal
- Strategy & Operations
- Marketing & Events
- Standards & Data
- Launch Initiative

Programs

-  **AESQ**
Aerospace Engine Supplier
Quality
[More Information](#)
-  **ASPQP**
Aerospace Standards and Part
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Questions?

