



1 Nov, 2019 | Connected Vehicle team

## A SUPPLIER VIEW OF JA6268 AND THE HRCS CONSORTIUM

2019 Innovations In Mobility Conference, Novi MI.

**Garrett**  
ADVANCING MOTION

# Agenda

- **Application of JA6268 for Design of Health Ready Turbocharger**
- **Supporting JA6268 as a Supplier of Connected Vehicle Systems**
- **Engagement with HRCS Consortium**
- **Next Steps**

# Application of JA6268 for Design of Health Ready Turbocharger

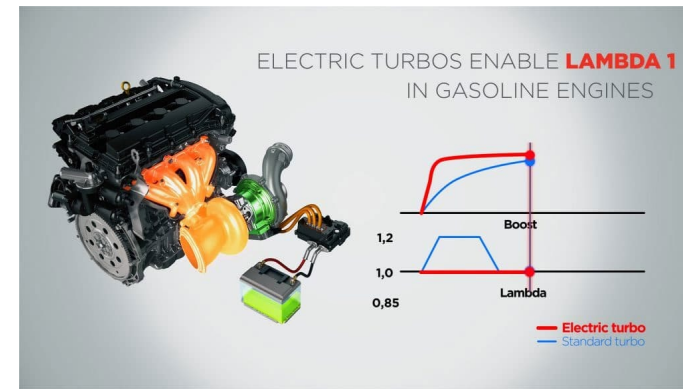
## Existing Turbocharger Designs



### JA6268 Compliance Strategy:

- Provide Algorithms for Computation of Condition Indicators
- Use Design Data Submittal to Specify Algorithm Input Parameters and Resulting Indicators
- Use Design Data to Model Relationships Between Failure Modes, Indicators and Corrective Actions
- Provide Web Service for Enhanced Diagnostic Support

## New, E-Turbo Designs



### JA6268 Compliance Strategy:

- Include Algorithms in Garrett Provided Control Software
- Use Design Data to Model Relationships Between Failure Modes, Indicators and Corrective Actions
- Provide Web Service for Enhanced Prognostic and Diagnostic Support

# Indicator Development for Turbocharger

4 health status monitoring approaches explored

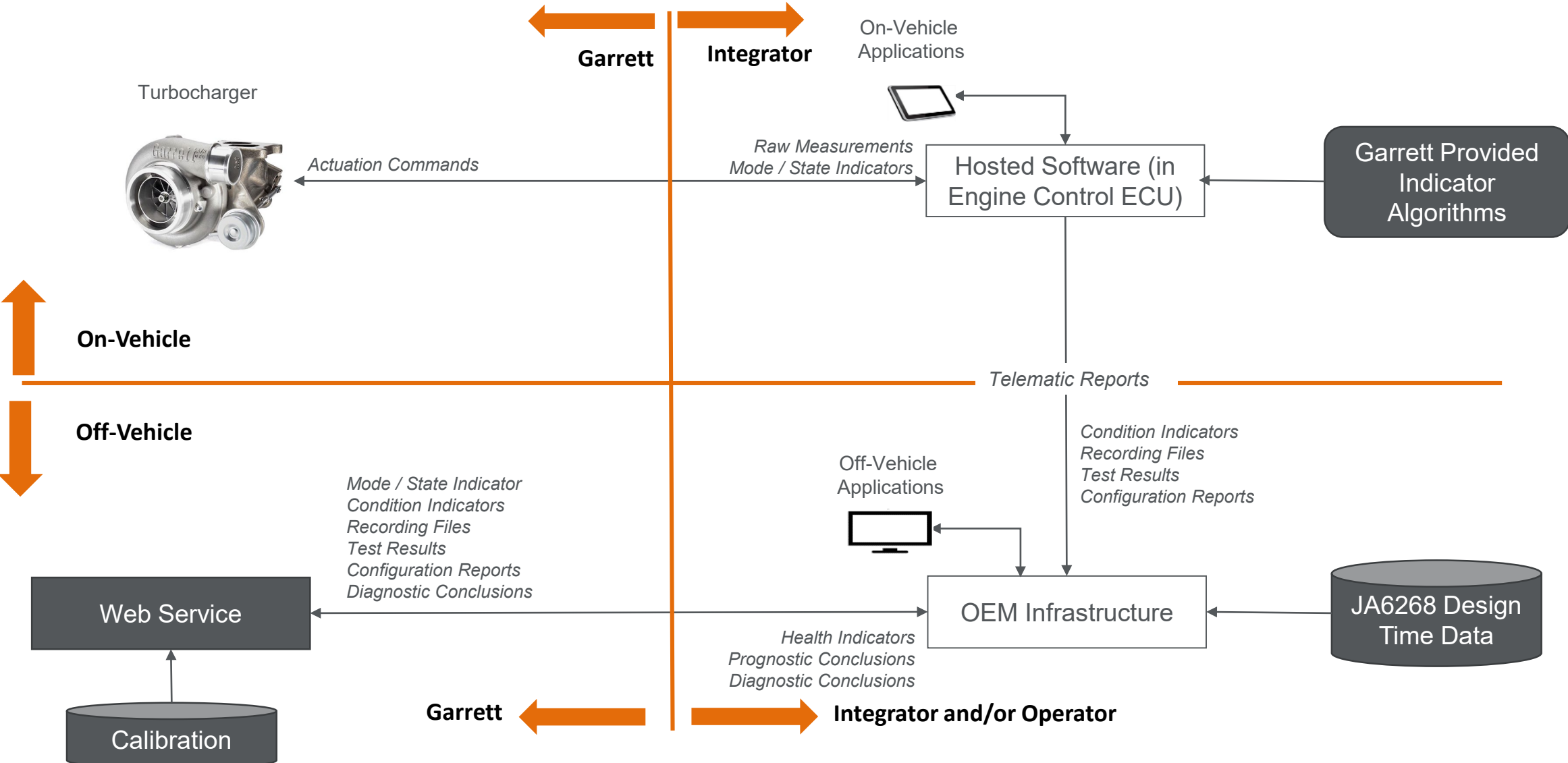
**Actuator wear** – several variants depending on the actuator signals available (adapted command, actuator signal and wiping sequence); real data validation + compensation for initialization delays (strategy B and C)

**Compressor efficiency degradation** – model-based and data-driven approach and physical compressor efficiency calculation; real data calibration + validation

**Turbocharger dynamics monitoring** – health status estimation based on either parity equation or bank of observers; evaluation of the disturbance detectability + real data verification

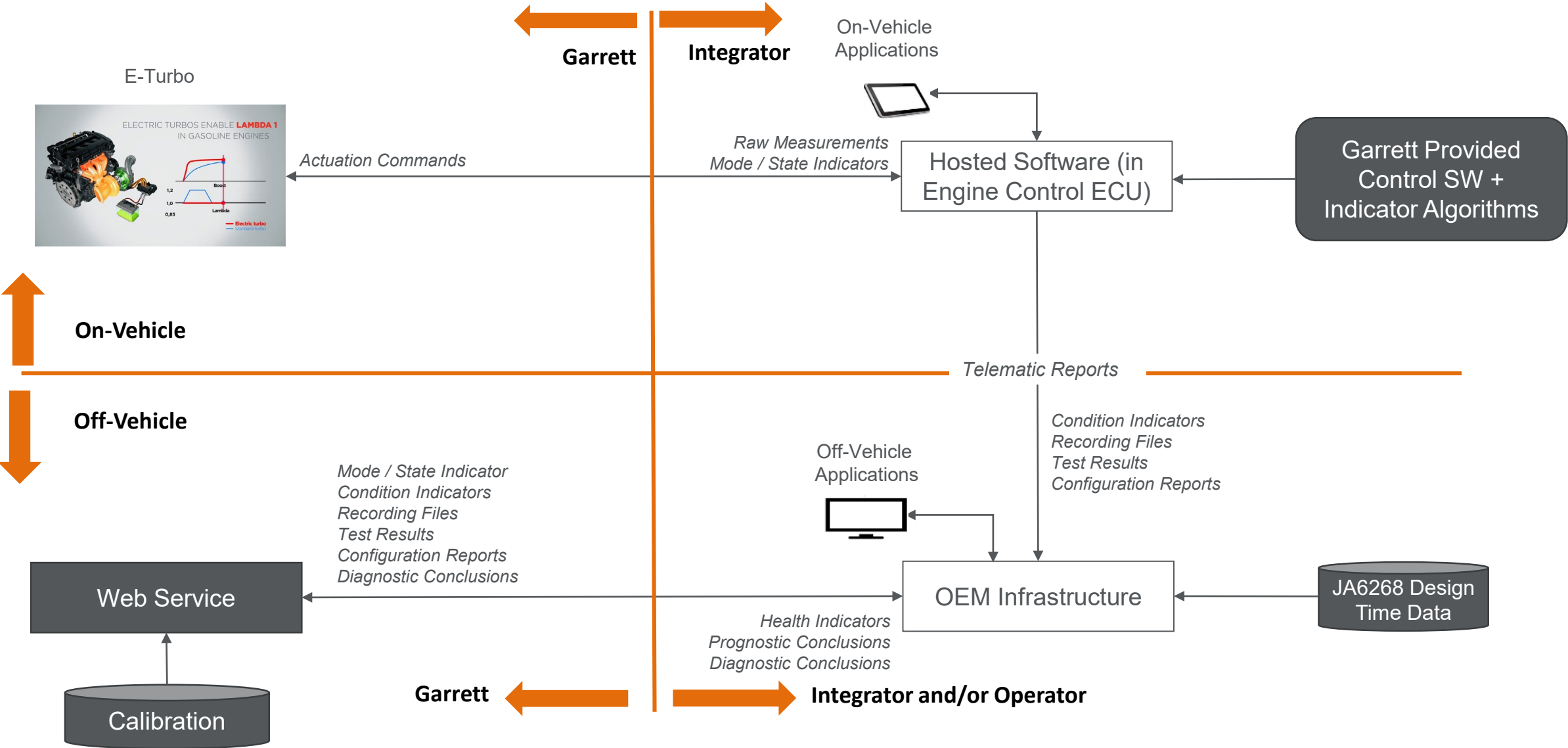
**Low cycle fatigue lifetime estimation** – data preprocessing and reduction ready, pre-measured fatigue curves at disposal; evaluation of quantization effects on the lifetime estimate accuracy

# Deployment for Non-Electric Turbochargers



Garrett Run-Time Software Computes New Condition Indicators and Web-Service Computes Diagnostic and Prognostic Results  
 Garrett Provide Design Time Data to Specify Algorithm I/O and Interpretation of Reported Indicators.

# Deployment for Electric Turbochargers



Garrett Run-Time Software Compute New Condition Indicators and Web-Service Computes Diagnostic and Prognostic Results  
 Garrett Provide Design Time Data to Support Interpretation of Reported Indicators.

# Garrett Turbocharger Stage 1 Registration

Garrett Has Started To Produce Stage 1 Design Data For Registration of Its Existing Turbochargers In HRCS Database.

IVHM Functional	Common IVHM Function or Process	General Description	% Coverage of Field Failures (if not provided, enter 0)
Data Acquisition (DA)	Data Management	System function and process to control, protect, manage, deliver and enhance the value of health state data and information for the user community.	85
	Data Transfer Interface	System function or system to download or communicate raw data, health state indicators and information for consumption by downstream systems.	
	Data Capture	System function may be a specialized data acquisition module that has analog feeds from sensors, collects processed data from a data bus or provides the software interface to a smart sensor.	
Data Manipulation (DM)	Feature Extraction	System function to manipulate data and compute certain statistical indicators from degradation (predictor) parameters.	80
	Data Normalization	System function to manipulate data and compute a limited range of values within a norm.	
	Data Processing	System function to manipulate data to compute health state indicator(s) or extract information for down stream systems.	
State Detection (SD)	Parametric Data Analysis	System function to process degradation parameter data streams captured in a predefined event, anomaly condition or using external equipment.	80
	Onboard Diagnostics	A dedicated system function for self-diagnostics and reporting of system failures.	
	Built-in-test (BIT)	The integrated system function that monitors and controls system self-tests to detect and report system failures to downstream systems.	
Health Assessment (HA)	BIT Filtering & Correlation	System function and process to manage false alarms, fault persistence and correlate primary and secondary diagnostic trouble (BIT) codes to operational capabilities.	75
	Fault Isolation Analysis	System function and process to resolve reported failure ambiguities using model-based diagnostics or multiple data observations.	
Prognostics Assessment (PA)	Time-to-fail Assessment	System function to monitor, record, assess and report equipment degradation parameter data and produce predicted performance life remaining estimates.	65
	Usage Monitoring & Assessment	System function to monitor, record, assess and report equipment life usage parameter data and produce predicted remaining useful life estimates.	
Advisory Generation (AG)	Decision Support Analysis	System function and process for the transformation and analysis of health state data and information to produce prescriptive actions for the user community.	80
	Health Reporting	System function to monitor, record and report health state data and information for consumption by downstream systems.	
	Caution Warning Indicators	System function to monitor, record, assess and report safety critical equipment failures and produce caution and warning indications for operators.	

SAE HRCS JA6268™ Registration		
Field	Description / Examples	Response
Function Self-Assessment, Stage 1, Part B Worksheet		
Fill in grey boxes		
<b>For Data Acquisition and Manipulation</b>		
Machine Readable Info Exchange? (select)	XLS templated form	XLS templated form
Machine Readable Conv of Raw Inputs to Eng Units? (select)	source code	XLS templated form
Severity of Failures? (Range: 5-1)	5-3	5-3
<b>For State Detection &amp; Health Assessment</b>		
Health Indicators ID'd? (Y/N)	Y	Y
Relationships/Models ID'd? (Y/N)	Y	N
Diagnostic Metrics 1? (specify range & type)	30-40%	20-30%
Type for Above	NTF (NFF)	NTF (NFF)
Diagnostic Metrics 2? (specify range & type)		2
Type for Above		Ambiguity Group Size
<b>For Prognostics Assessment &amp; Advisory Generation</b>		
Typical RUL Notice?	14.0	60.0
Units for Above	Days	Days
Typical Std Dev for RUL? (specify units if applicable)	4.0	10.0
Units for Above	Days	Days
Prognostic Metrics 1? (specify range & type if applicable)	99%	85%
Type for Above	TPR	TPR
Prognostic Metrics 2? (specify range & type if applicable)	90%	0.15%
Type for Above	FPR	FPR

**STAGE 1: FUNCTIONAL**  
Part B asks 9 Supplemental Questions

- For Data Acquisition
  - Machine Readable Info Exchange?
  - Machine Readable Conv of Raw Inputs to Eng Units?
  - Severity of Failures?
- For State Detection
  - Health Indicators ID'd?
  - Relationships/Models ID'd?
  - Diagnostic Metrics?
- For Prognostics Assessment & Advisory Generation
  - Typical RUL Notice?
  - Typical Std Dev for RUL?
  - Prognostic Metrics?

SAE HRCS JA6268™ Registration

Dropdown field definitions:

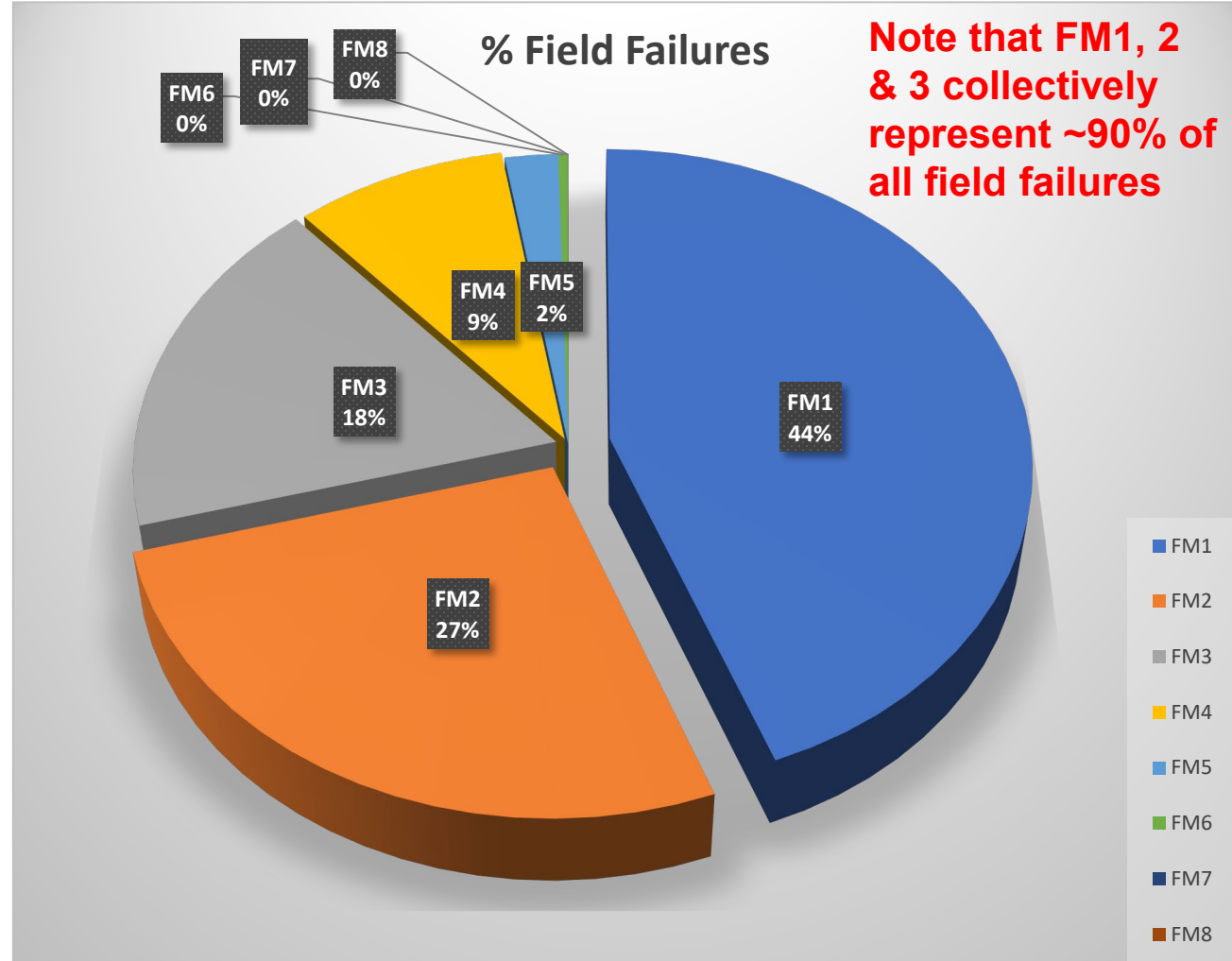
<select>	<select>	<select>	<select>
Y	Hours	TPR	N/A
N	Days	FPR	XLS templated form
	Weeks	TNR	ACCDB templated form
	Months	FNR	MS Word templated tables
	Cycles	PPV	XML templated form
	Engine Hrs.	NPV	source code
	Cycles	FDR	pseudo code
	Engine Hrs.	FOR	
	Operation Hrs.	Cd Coverage	
	Other	NTF (NFF)	
		Ambiguity Group Size	
		RUL Std Dev	

Preliminary Data For Stage 1 Registrations Have Been Submitted Stage 2 And Stage 3 Registrations Are Being Negotiated With Several OEMs.

# Stage 2 - Failure Modes Prioritized by Frequency of Occurrence (Hypothetical example)

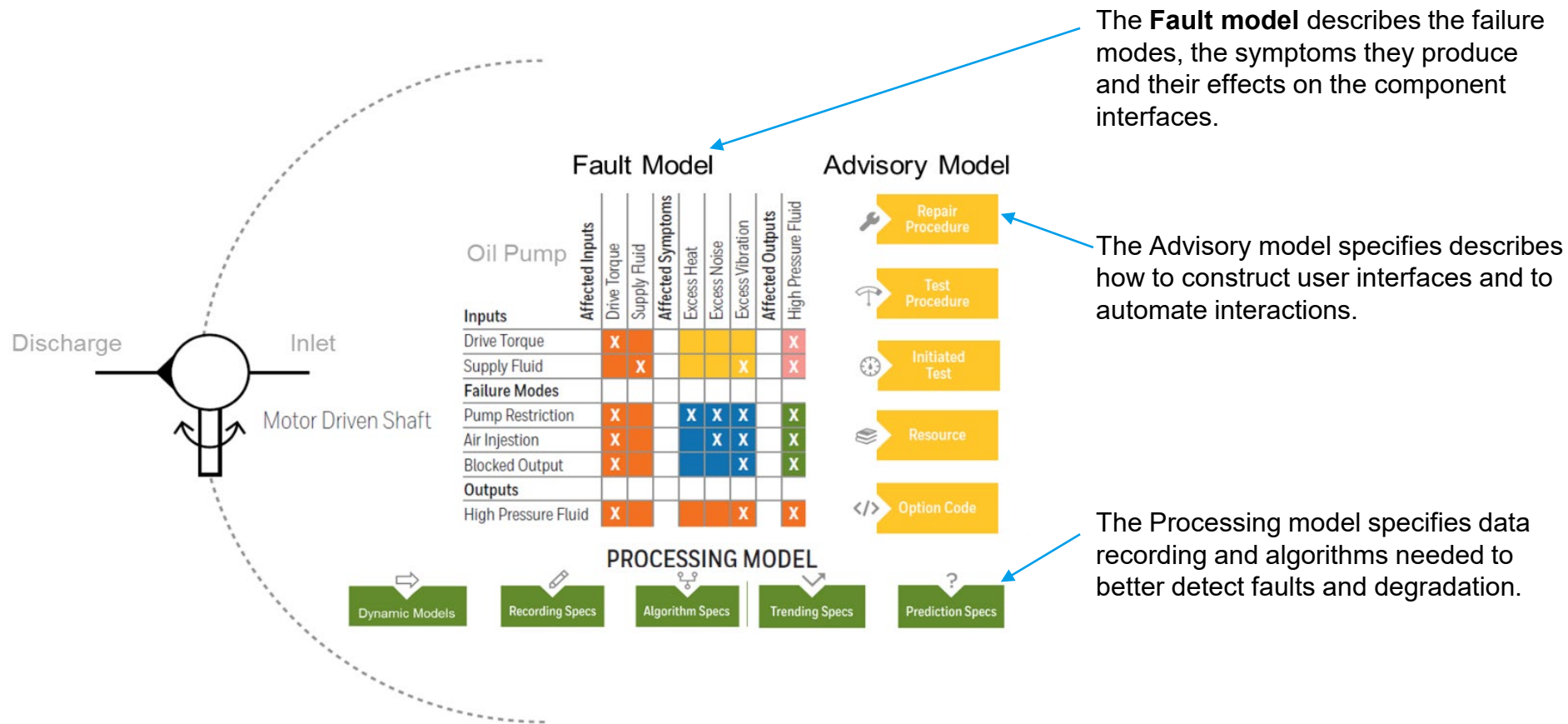
Failure Mode	IPTV Expected in 1st 5* Years	% Field Failures
FM1	10.0000	44.2605
FM2	6.0000	26.5563
FM3	4.0000	17.7042
FM4	2.0000	8.8521
FM5	0.5000	2.2130
FM6	0.0900	0.3983
FM7	0.0030	0.0133
FM8	0.0005	0.0022
Total	22.5935	100.0000

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



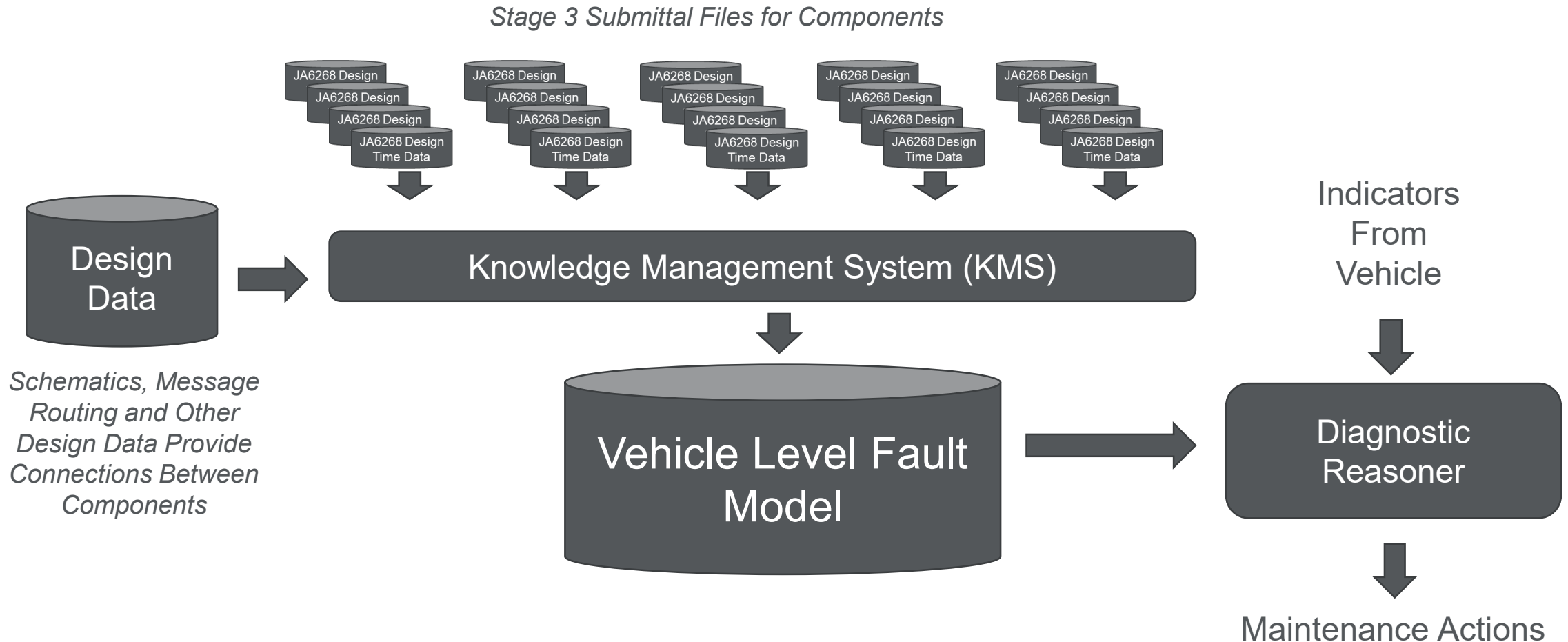


# Example Stage 3 Workbook – Primary Diagnostic Data



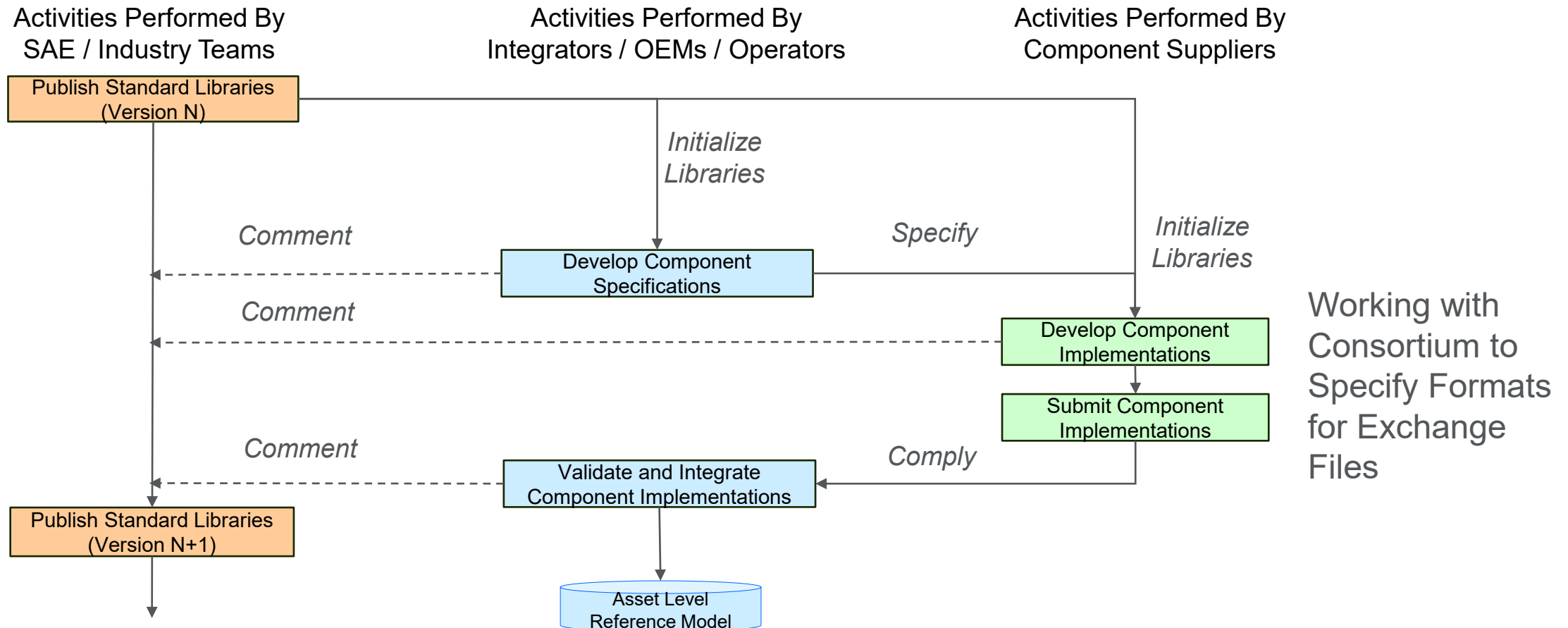
Design-time data exchange provides description data needed for IVHM functions and user interfaces (data logging, fault detection, degradation detection, trending, fault isolation, prognosis).

# Supporting JA6268 as a Supplier of IVHM Solutions



Garrett JA6268 Compliant IVHM Solutions Integrate Design Time and Run-Time Data From All Suppliers to Greatly Reduce the Cost to Deploy Predictive Maintenance Solutions.

# HRCS Proposed Design Data Exchange Workflow



Mechanism to create a machine interpretable IVHM data exchange

# Next Steps

- **Garrett Will Continue to Develop Algorithms and Design-Time Data To Register Our Turbochargers as Health Ready.**
- **Garrett Will Deploy Web-Services to Complement On-Vehicle and OEM Hosted Algorithms.**
- **Garrett Will Work with HRCS to Formalize Standards for Stage 3 Design-Time Data Exchange.**
- **Garret Will Continue to Adapt IVHM Solution Elements to Be Fully JA6268 Compliant.**

# Garrett

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