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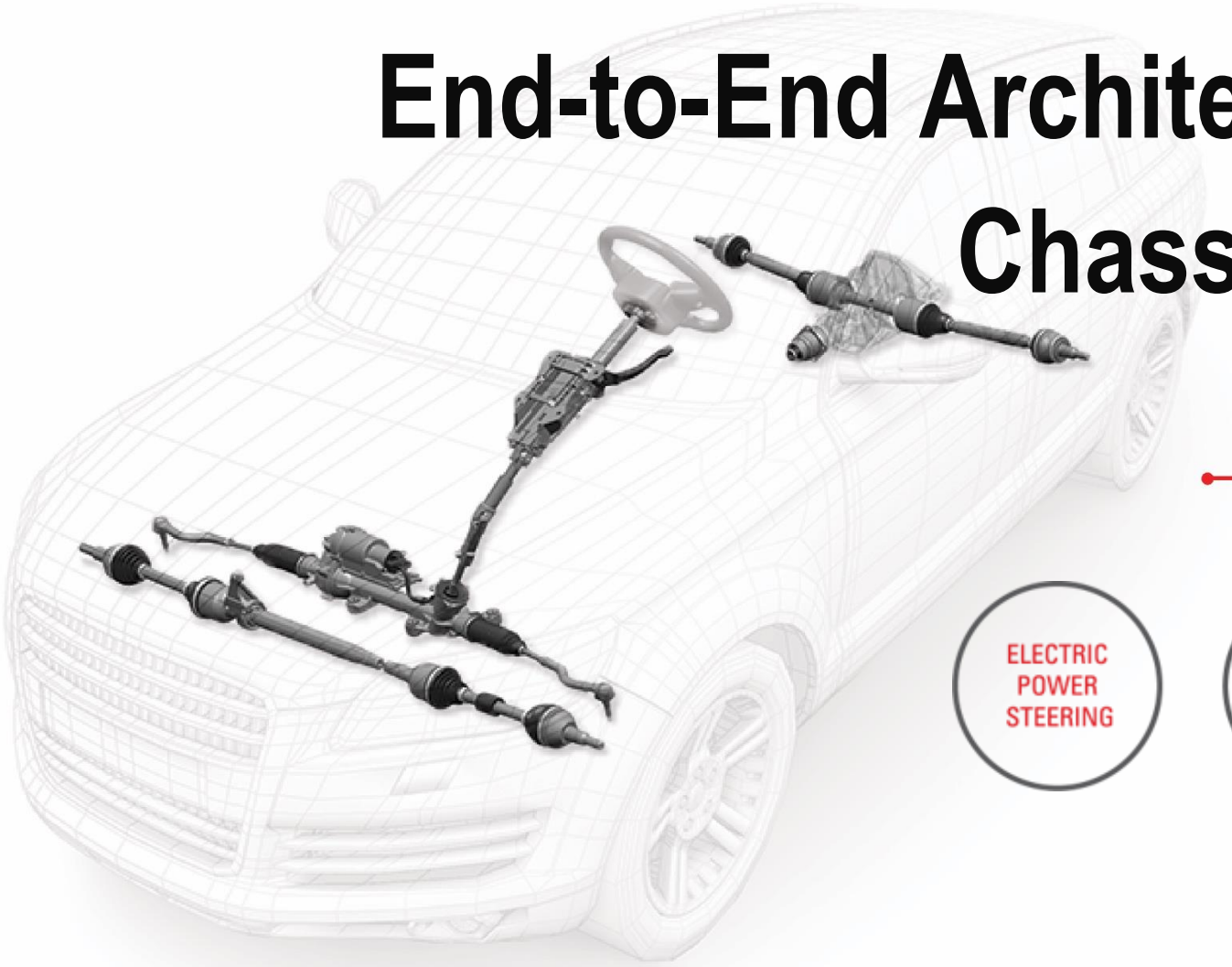
End-to-End Architecture and Methods for Chassis Health Management



Joe Klesing, Peter Schmitt

ELECTRIC POWER STEERING

COLUMNS & INTERMEDIATE SHAFTS

DRIVELINE SYSTEMS

HYDRAULIC POWER STEERING

ASSISTED & AUTOMATED DRIVING ENABLERS

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What does a Jet Engine have to do with Vehicle Health Management?

Source: Johnny Saldivar/U.S. Air Force

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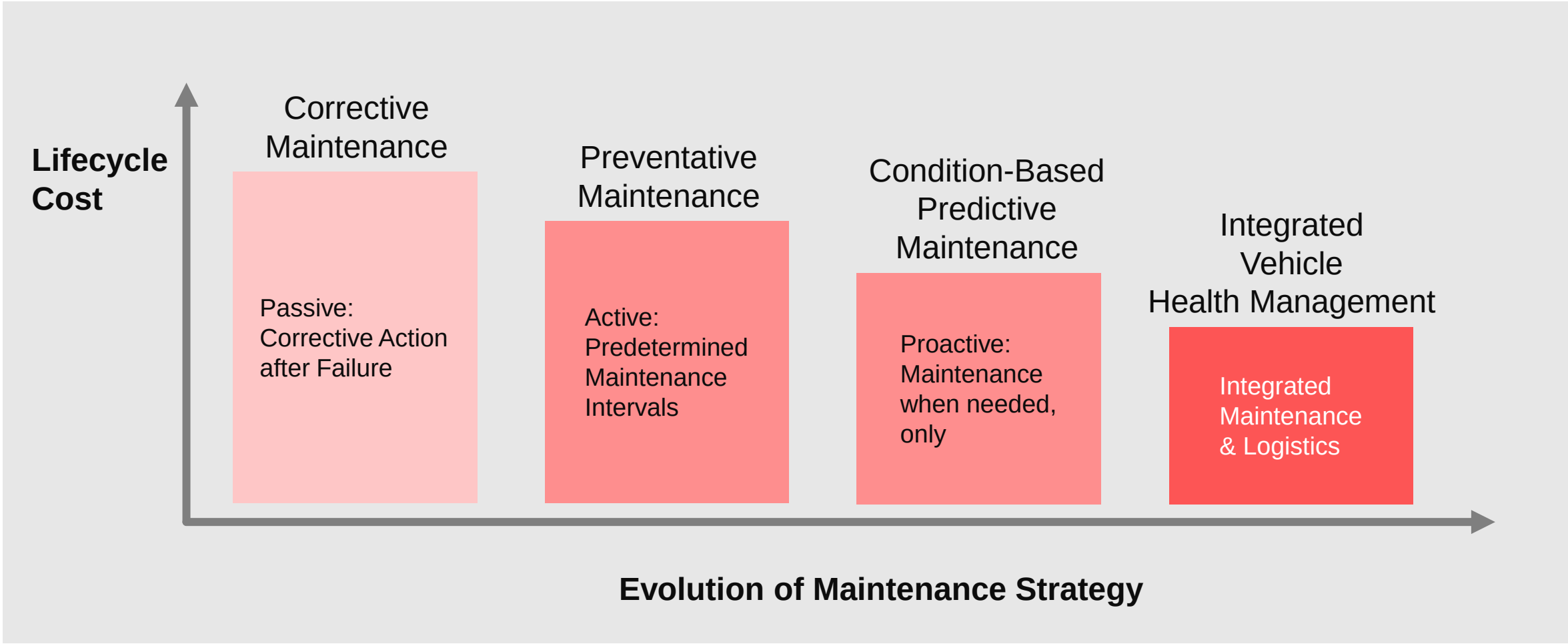
Evolution of Maintenance Strategies



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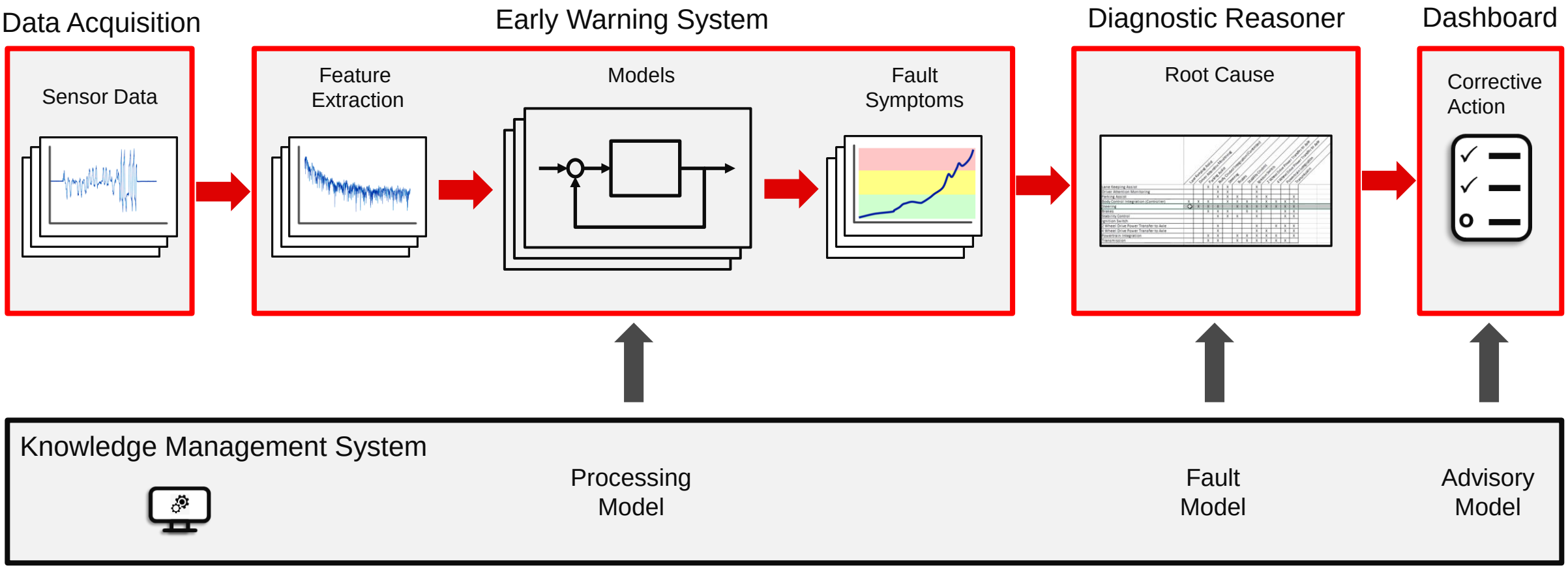
Vehicle Health Management Framework

Use Vehicle Data to assess Health, predict TTF, determine Root Cause



Run-Time
Design-Time

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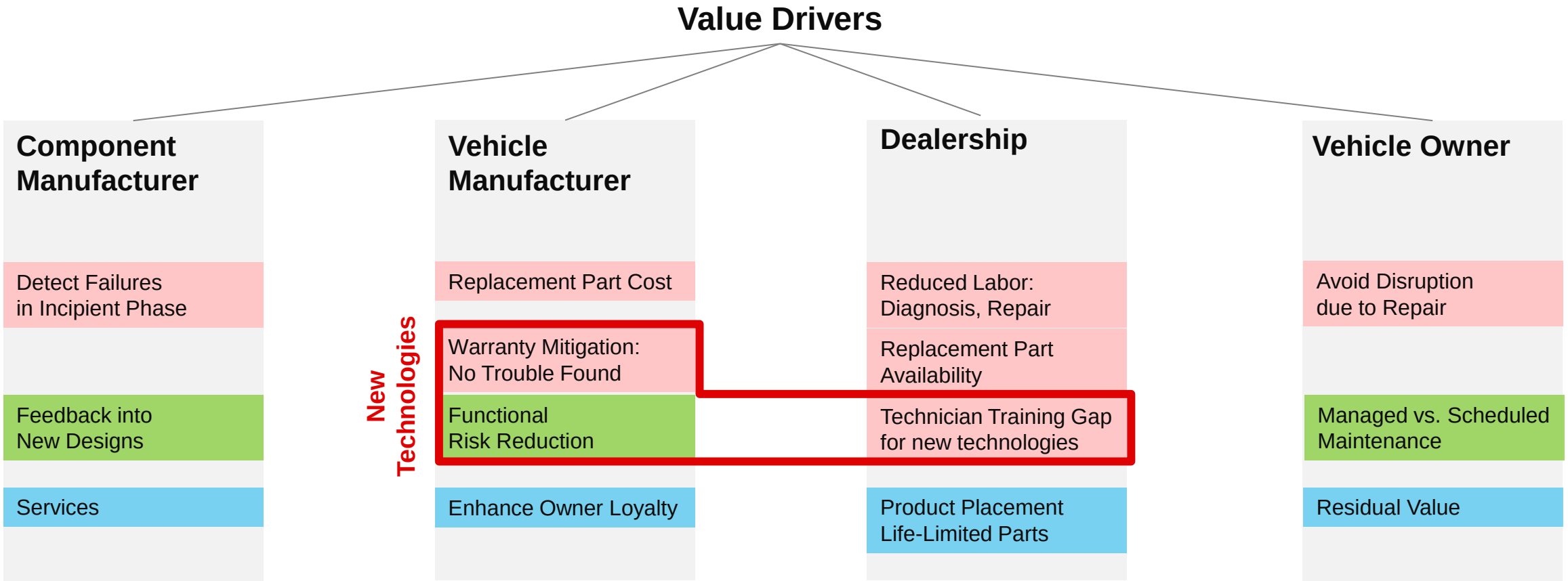
Value Drivers for Vehicle Health Management

Fit-for-Use, Operational Efficiency & Customer Service Experience



Cost Avoidance

Cost Reduction

Revenue Increase

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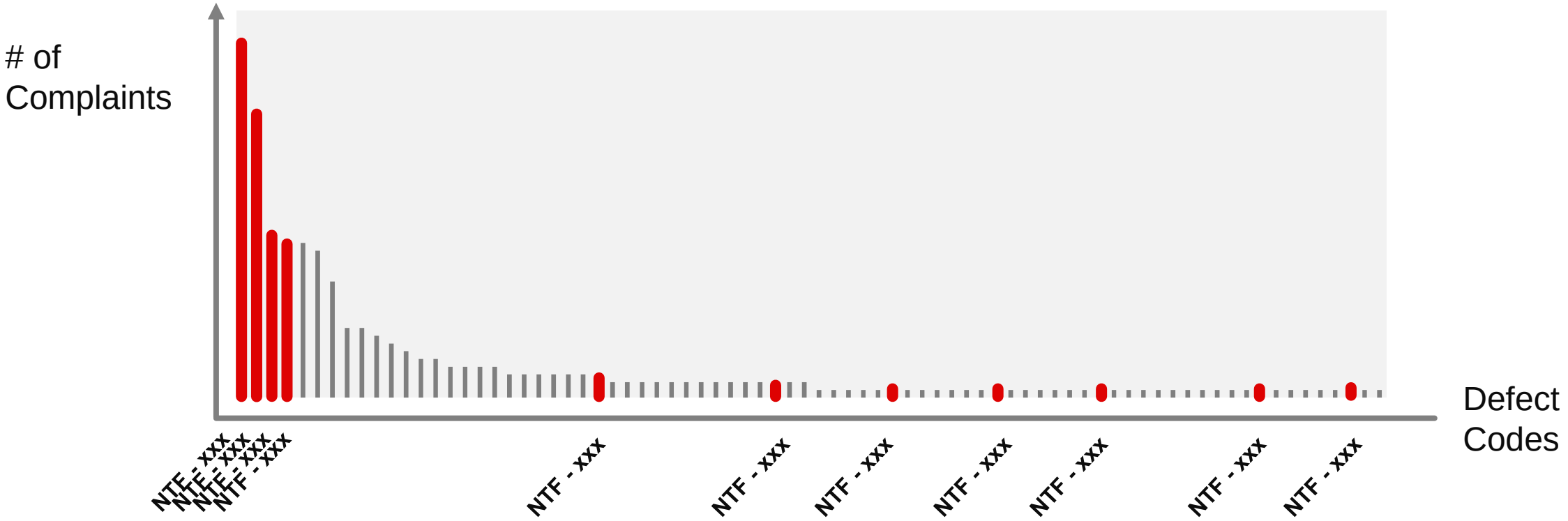
Example Distribution of EPS Warranty Items

30 - 45% Classified as No Trouble Found



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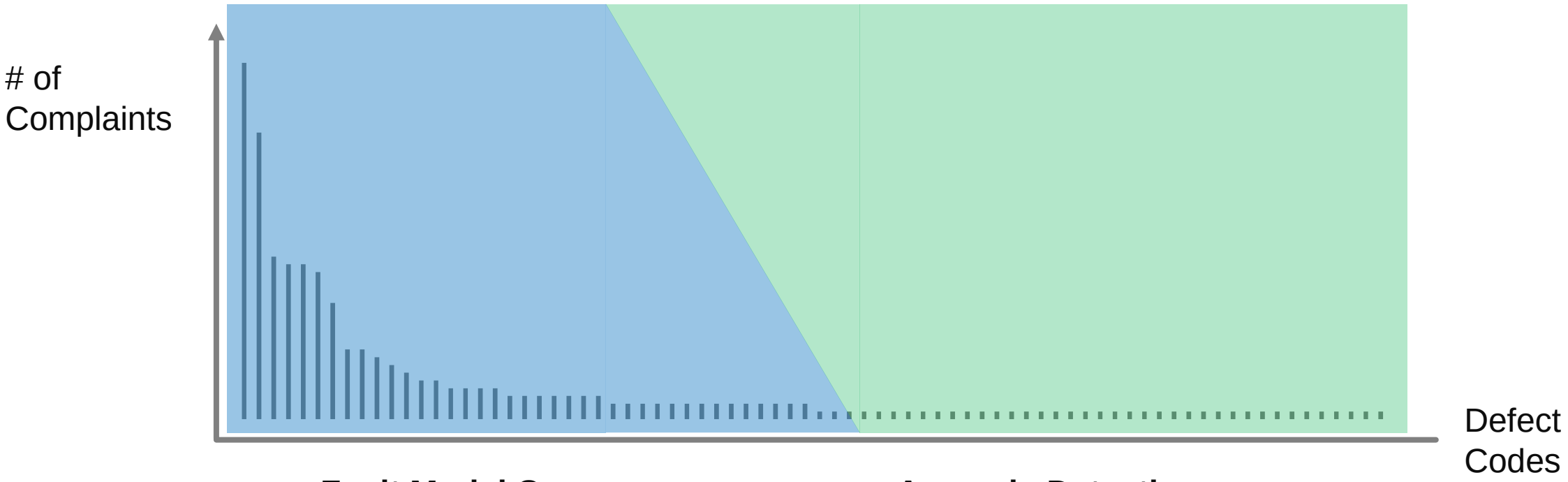
Example Distribution of EPS Warranty Items

Combination of Fault Models & Anomaly Detection



Fault Model Coverage

- Detect each fault
- Improved accuracy for higher occurrence Faults

Anomaly Detection

- Detect “normal vs. abnormal” behavior
- Capture lower occurrence faults at lower cost
- Offers additional support for higher occurrence faults

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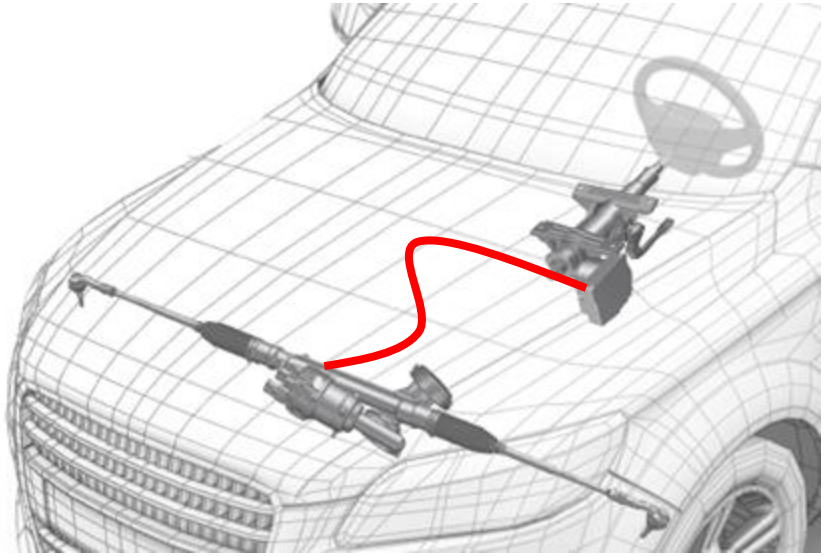
Example New Technology

VHM Provides Additional Layer of Risk Reduction



- Redundant Communication & Processing Paths
  ensure Fail-Operational System Safety
- Layers of Redundancy impact
  a. Component cost
  b. System reliability
- Prognostics & Diagnostics
  reduce probability of failures during operation in the field
  while supporting maintenance technicians
  dealing with technology innovations

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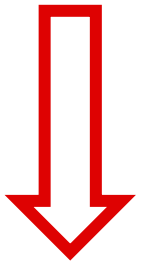
Evolving Industry Capabilities

from Cloud-Enabled Monitoring to Integrated Vehicle Health Management

SAE JA6268 IVHM Classification

	SAE Level	Capability	Description	Data Resources	Models
Manual Diagnostics & Repair	0	Limited On-Vehicle Warning Indicators	Scheduled Maintenance or Operator Alert	On-Vehicle	Paper Manuals
	1	Enhanced Diagnostics	Service Technicians use Automated Scanners	+ Service Bay	"
	2	Telematics provides Remote Real-Time Data	Central Monitoring of Vehicle	+ Cloud	"
Augmented by Prognostics & Predictive Analytics	3	Proactive Component-level Alerts	Provide Health Status before Problem occurs	"	Component Health Models
	4	Integrated Vehicle Health Management	Estimate Remaining Useful Life	"	+ Vehicle-Level Health Models
	5	Self-Adaptive Health Management	Extend Vehicle Operation & enhance Safety	"	+ IVHM Capability integrated into Controls

Industry Level Today



Source: adapted from SAE Surface Vehicle / Aerospace Recommended Practice JA6268, Design & Run-Time In-formation Exchange for Health-Ready Components, 2018

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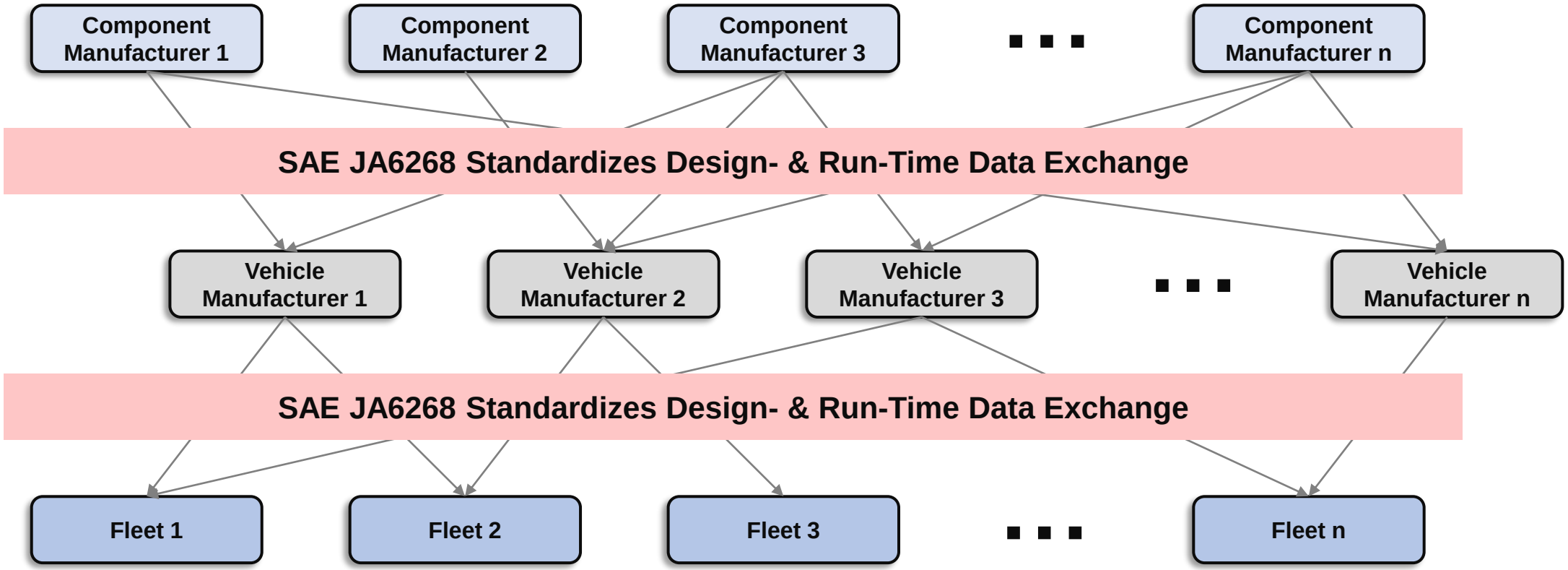
Barriers To Effective Diagnostics In The Industry

Multiple Players, Lack Of Uniform Nomenclature, Evolving Architectures



Source: adapted from T. Felke, Future of Vehicle Health Management with SAE JA6268

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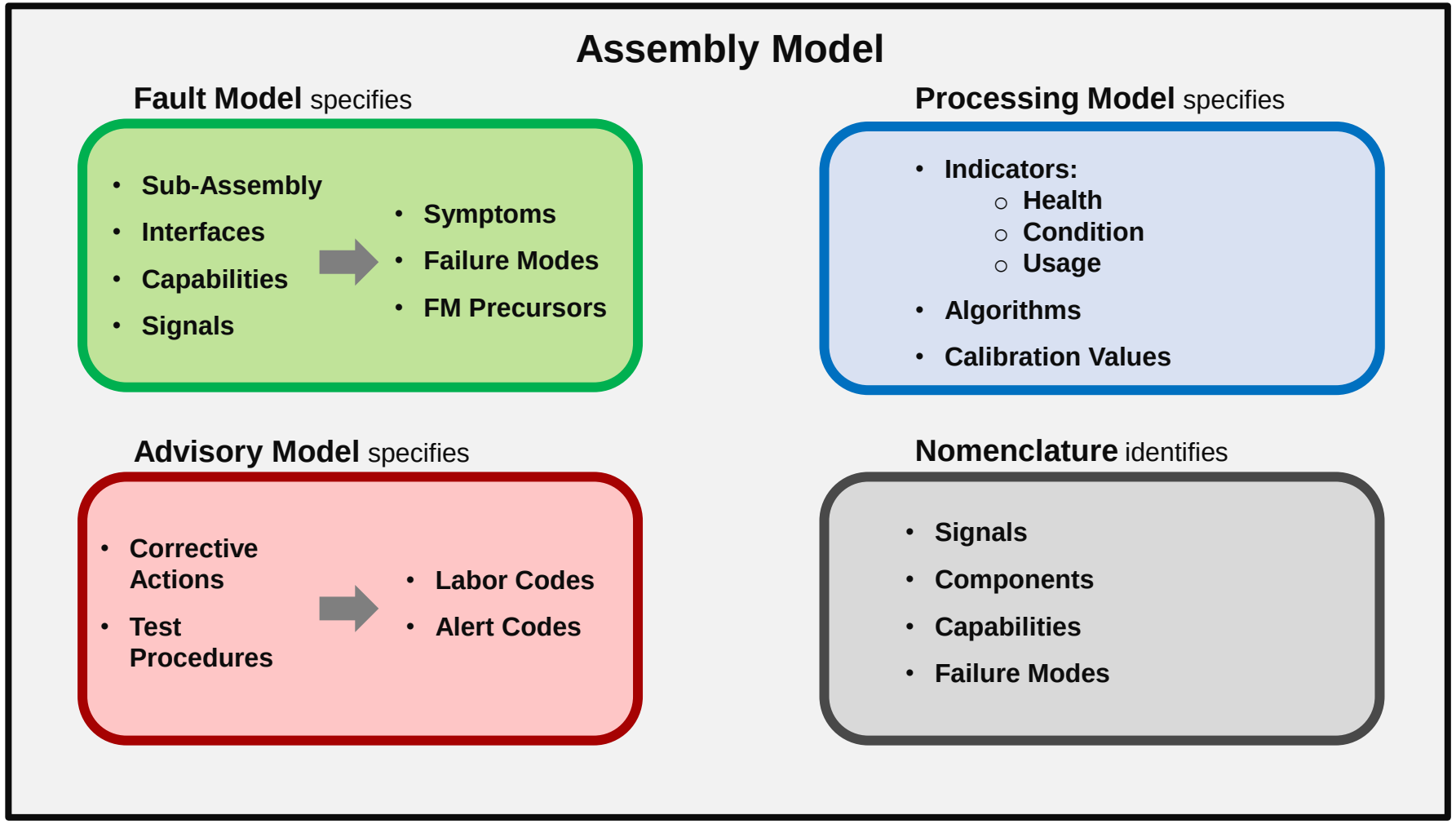
Health Ready Components Data Sheet Schema

Covers All IVHM Functions of Component & Systems



Source: adapted from T. Felke, Future of Vehicle Health Management with SAE JA6268

HRCS™ Health-Ready Components and Systems A Program of SAE ITC
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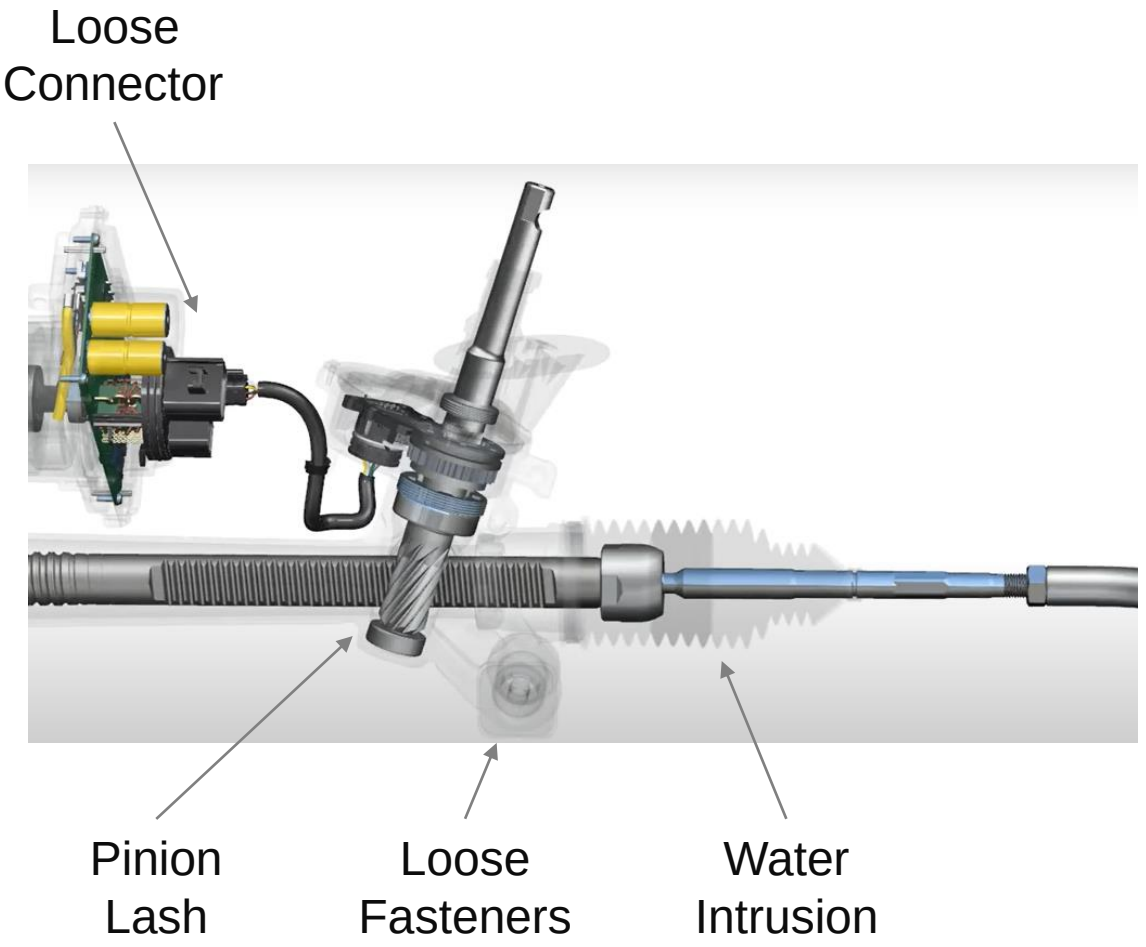
Use Case

Off-Road Damage On Electric Power Steering



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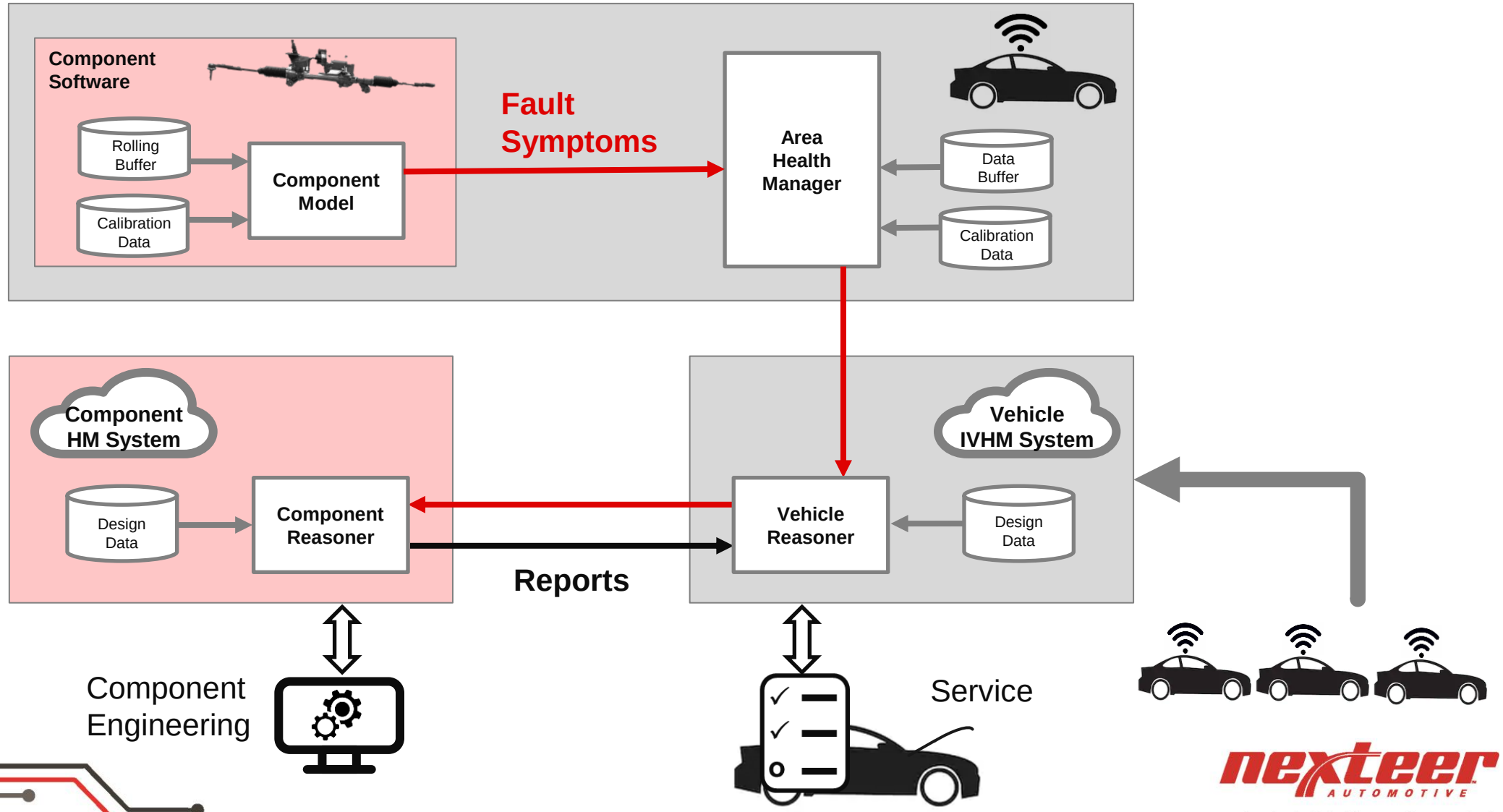
SAE JA6268 Compliant System Architecture

Indicator Computation In Component and Area Health Managers …



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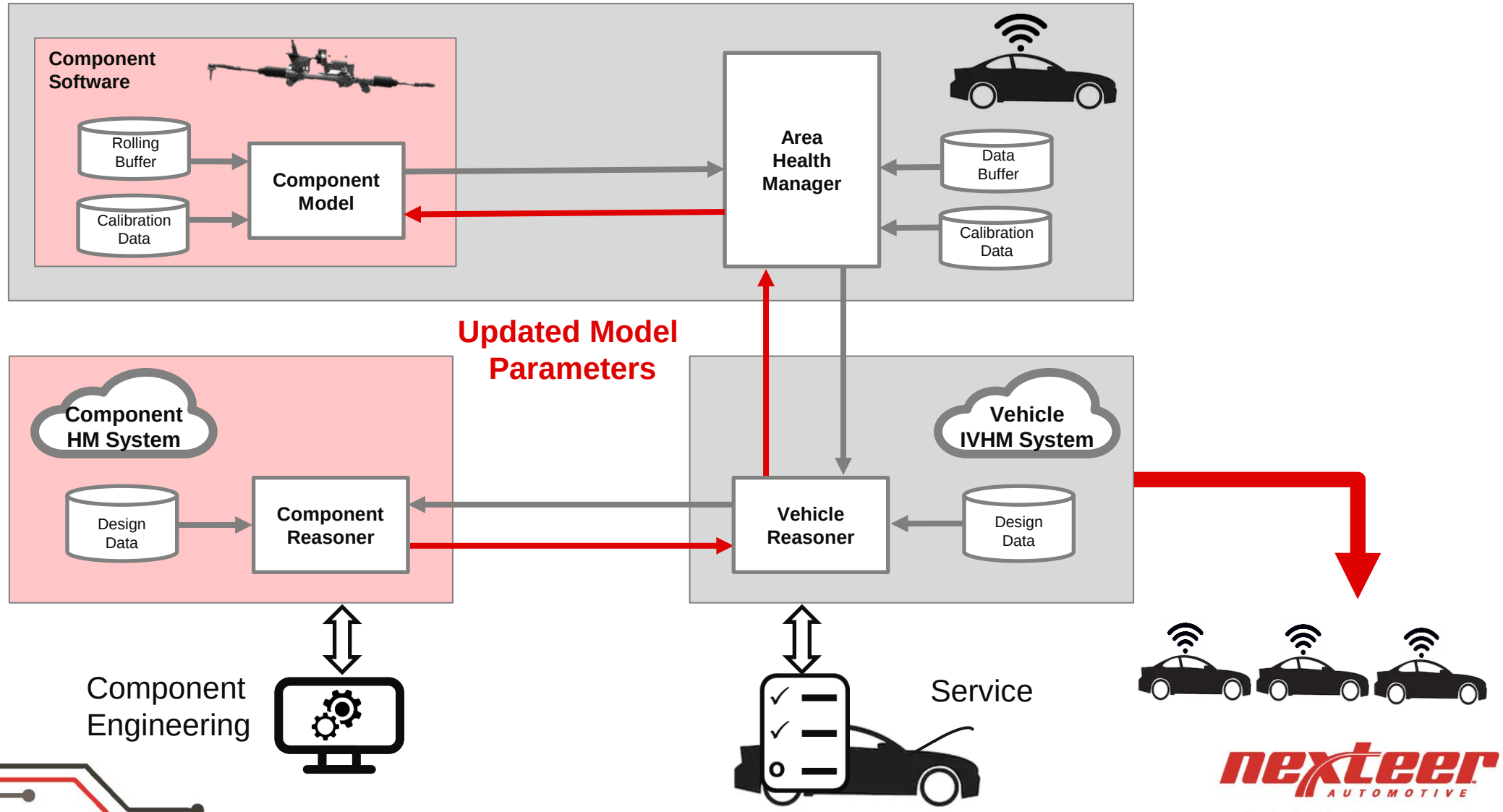
SAE JA6268 Compliant System Architecture

… While Any Vehicle Learns From Every Vehicle



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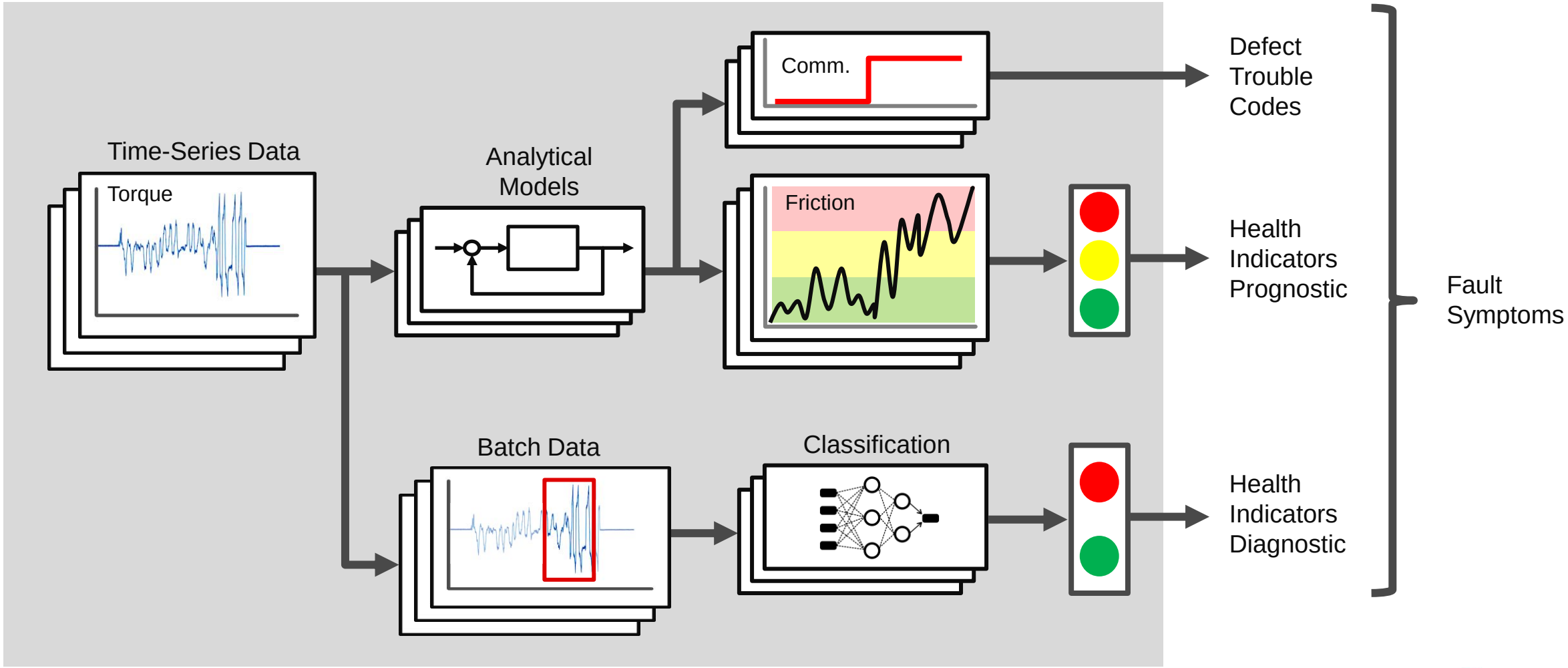
System Architecture

Early Warning System Generates Fault Symptoms for Reasoner



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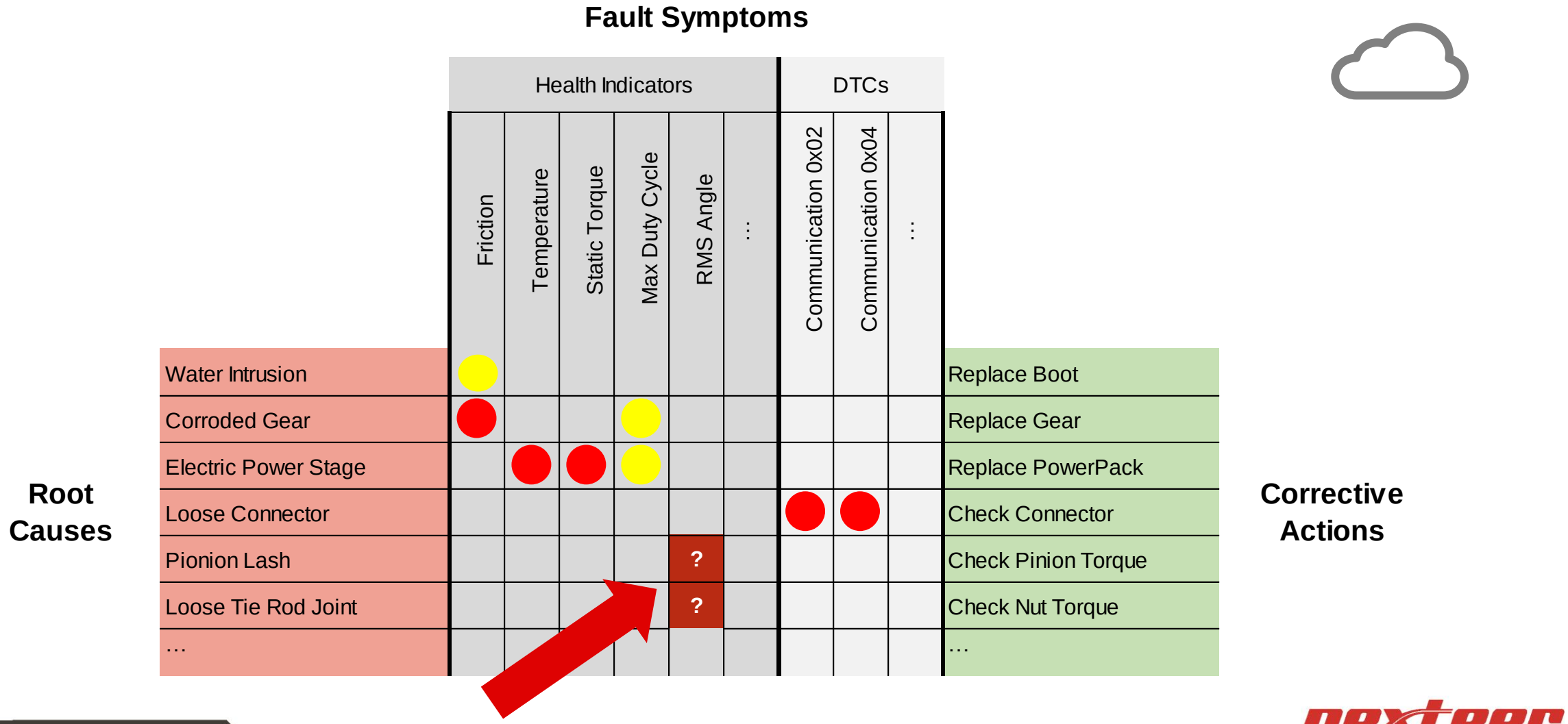
Fault Model Determines Root Cause

Classic Reasoner Requires Clear Alert Levels for Classification



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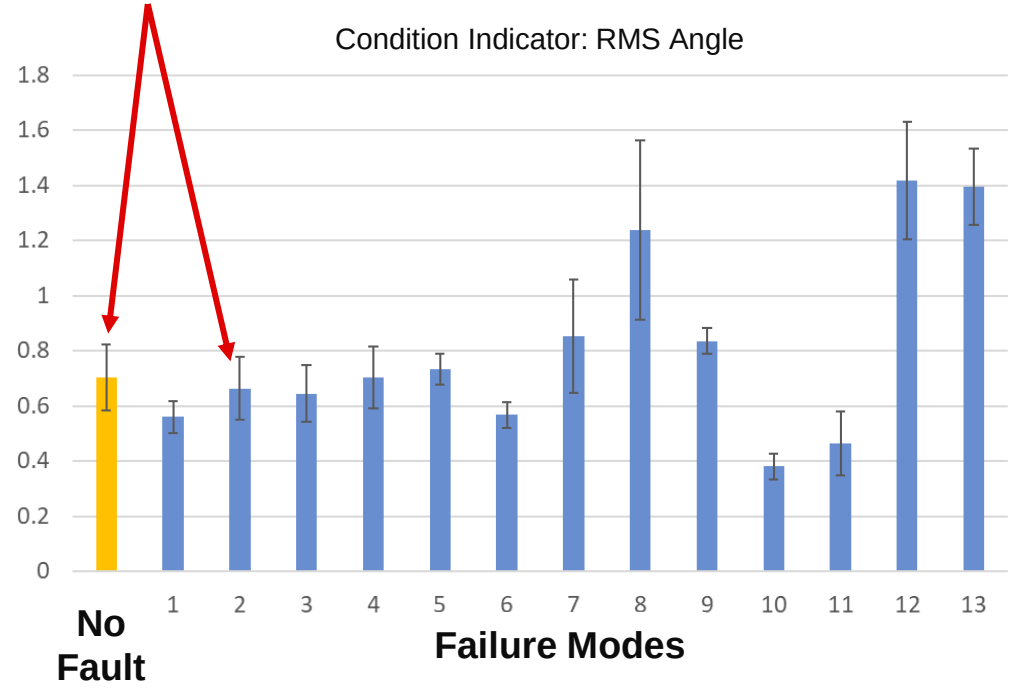
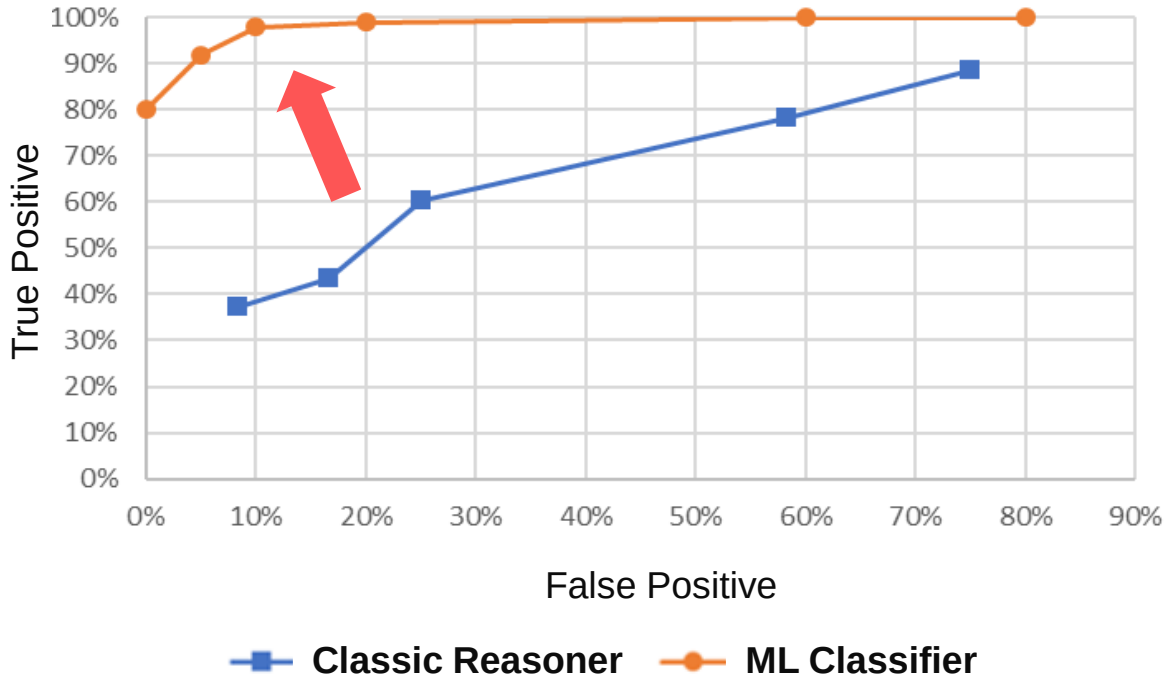
Some Failure Modes Require ML Classifiers

And Time-Series Data To Determine Root Cause

Good vs. Bad difficult to discriminate





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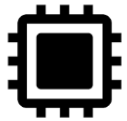
Process Summary
& SAE JA6268 Health Management Stack

Component Manufacturer

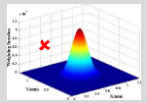
Vehicle Manufacturer



Digital Twin of Component
Health Indicator:
Root Cause:

API

Processing: Do-or-Delegate
Trending: vehicle vs. fleet



API

On-vehicle Aggregation & Buffering of Fault Symptoms

API

Fault Symptoms

Corrective Actions
Labor Codes

Driver alert

Nomenclature

- Processing Model
- Fault Model
- Advisory Model

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Summary

- Vehicle Health Management creates Value for Manufacturers, Dealerships and Consumers by improving Fit-for-Use, Operational Efficiency and creating a better service experience.
- The System Architecture spans Components, Area Health Manager and Backend Instances of Vehicle and Component Reasoners.
- Machine-Learned Classifiers based on time-series Data may improve True vs. False Positive detections.
- SAE JA6268 provides a cross-industry approach to Health Management by standardizing Design & Runtime Data Exchange.
- Health Ready Components and Systems (HRCS) strategy group by SAE supports the introduction of SAE JA6268 into the automotive industry.
  Learn more at https://www.sae-itc.com/programs/hrcs .

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