Update to SAE HM-1 on HRCS Consortium Progress

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HRCS UPDATE: COLLABORATION WITH TMC

- Engaged with American Trucking Associations (ATA) Technology & Maintenance Council (TMC)
- Launched two pilot studies (January 2021- ongoing):
  - Volvo- Garrett- ABF Freight Lines
  - SEFL- DG Technologies- Saferide Technologies
- HRCS has signed an MOU with TMC to collaborate on developing and advancing Integrated Vehicle Health Management (“IVHM”) techniques in the commercial trucking industry
- HRCS has signed a VMRS (Vehicle Maintenance Reporting Standards) License Agreement with TMC to incorporate VMRS coding within commercial trucking standard templates layered on top of SAE standards such as J1939, J2012, and J1972. This will accelerate development and acceptance within the sector.
- Joint Press Release issued week of October 18, 2021. Social Media, SAE Periodicals announcements to follow.

HRCS UPDATE: COLLABORATION WITH TMC

TMC Future Truck IVHM Sub Committee: 5-year horizon and beyond

"The Future Truck Committee mission shall be: To improve transport equipment, its maintenance and maintenance management by efforts to influence future equipment design."

- Education
- Position Papers
- Policy Positions
- Pilot Programs: Volvo- Garrett- ABF Freight Lines SEFL- DG Technologies- Saferide Technologies
- Identify topics for Study Group Task Forces
- Next Steps for Health Maintenance within ATA/TMC as an Industry Group

Study Groups are ongoing committees that identify industry challenges with respect to equipment and maintenance.

Task Forces are short-term subcommittees of Study Groups that solve problems, usually through the development of a TMC recommended Practices.

HRCS UPDATE: COLLABORATION WITH TMC

Study Group S5 (Fleet Maintenance) has taken over the JA6268 HRCS work from Future Truck with the start of the S5 HRCS Task force.

- Define ATA/TMC process to maintain VMRS mapping to JA6268
- Define data exchanges required within an asset system and beyond the asset from a fleet perspective
- Publish a Recommend Practice for the use of JA6268 within ATA/TMC Study Groups and Task Forces from a Fleet Perspective

Areas of focus for Study Groups, and Task Forces to be influenced by JA6268 and HRCS:

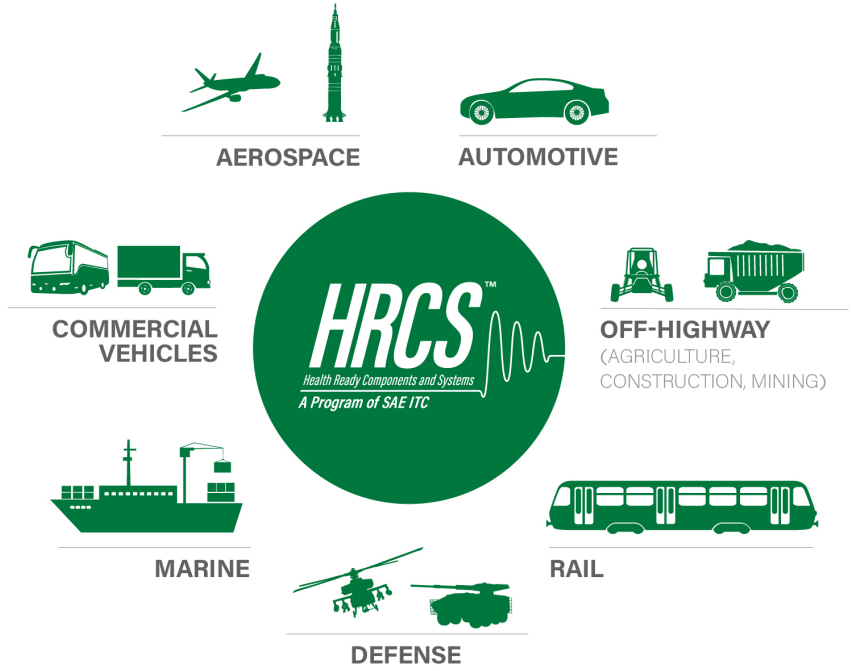
- Server to server communications compliant to JA6268
- JA6268 HRCS compliant data provided by assets
- Smart Trailer
- Future Propulsion
- Electromechanical Braking
- ADAS
- Autonomy

CODING AND TAXONOMY

- We realized that a focused 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.

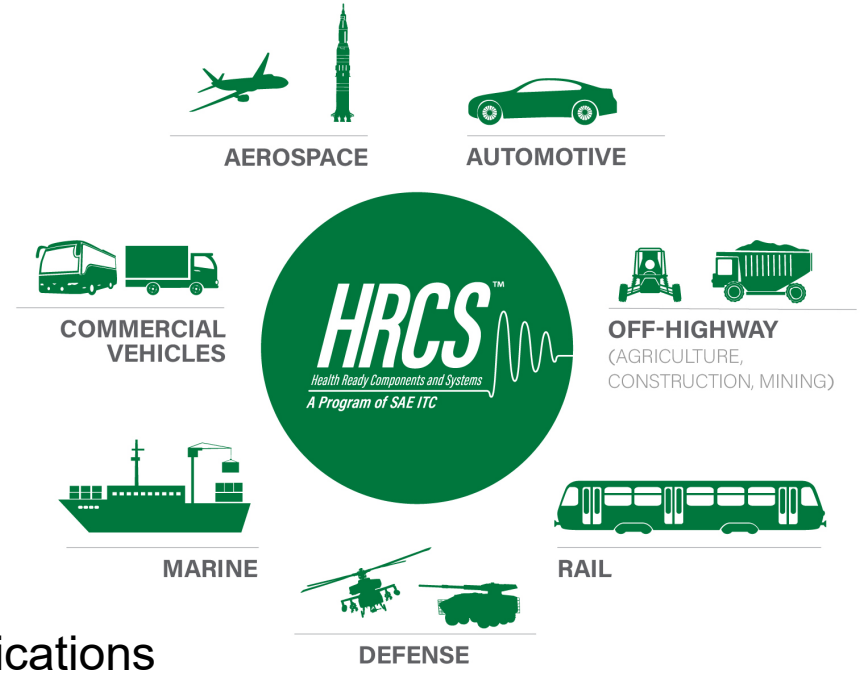
- This approach will support a mechanism to develop and manage standard mapping between HRCS and existing sector specific codes (such as VMRS in trucking, ATA codes in aviation, or OBD codes in automotive).

- Sector specific codes will be incorporated to accelerate acceptance and improve granularity where feasible.



HRCS MULTISECTOR STRATEGY

- HRCS is promoting the application of IVHM in industry
- Targeting mobility- seven sectors
- Developing content relevant across all mobility sectors
- Actions:
  - organizing pilot studies
  - developing standards, best practices, and policies
  - creating standard templates and worksheets to standardize communications



HRCS POLICY STATEMENTS

- **HRCS Consortium™ intends to periodically issue broad policy recommendations.**
  - These statements represent the collective wisdom of our consortium membership and are intended to encourage thoughtful discussion on topics of strategic importance to industry which may impact the successful implementation of Integrated Vehicle Health Management (IVHM) technology solutions. The current set of position statements include:
- **Operating Data Ownership** (May 2021):
  - Sophisticated components installed in modern vehicles can store and transmit large volumes of data regarding the operating condition of individual components, systems or the entire vehicle. This data is valuable for predictive and comparative purposes in a variety of contexts. This statement is intended to clarify the rightful owner of that operating data as well as elucidate some of the key issues relevant to this question.
- **Right to Repair** (pending release):
  - This is a special case of the “Operating Data Ownership” policy. This policy is focused on maintenance-related information and does not apply to clearly proprietary design content such as control logic. It is intended to ensure that all repair organizations have access to all necessary info.

POLICY STATEMENTS: DATA OWNERSHIP & RIGHT TO REPAIR

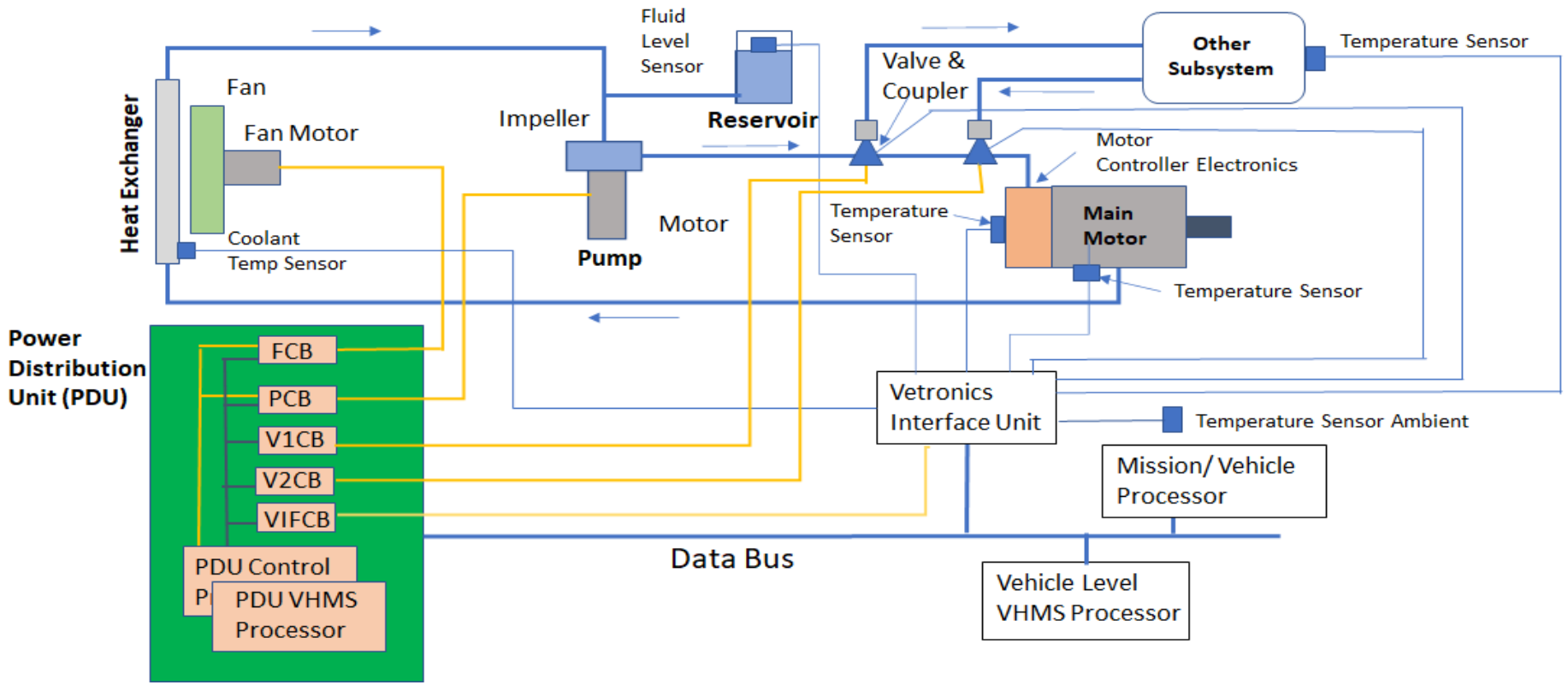
- **Data Ownership** addresses:
  - Operating data produced by an asset (vehicle, aircraft, …)
  - Rightful owner of the data
  - Sharing of data among those with different perspectives
  - Safety & legal implications
  - Design IP, maintenance and servicing of the asset

- **Right to Repair** addresses:
  - Owners and repair shops' right to maintenance-related info to safely service and maintain assets in both automotive & aerospace
  - Existing and proposed legislation as well as governmental regulations
  - Customer support services incl. VHM & Proactive Alerts
  - Design IP of OEMs and Suppliers
  - Vehicle owner and operator privacy rights

HRCS Policy Statements: https://www.sae-itc.com/programs/hrcs/positions

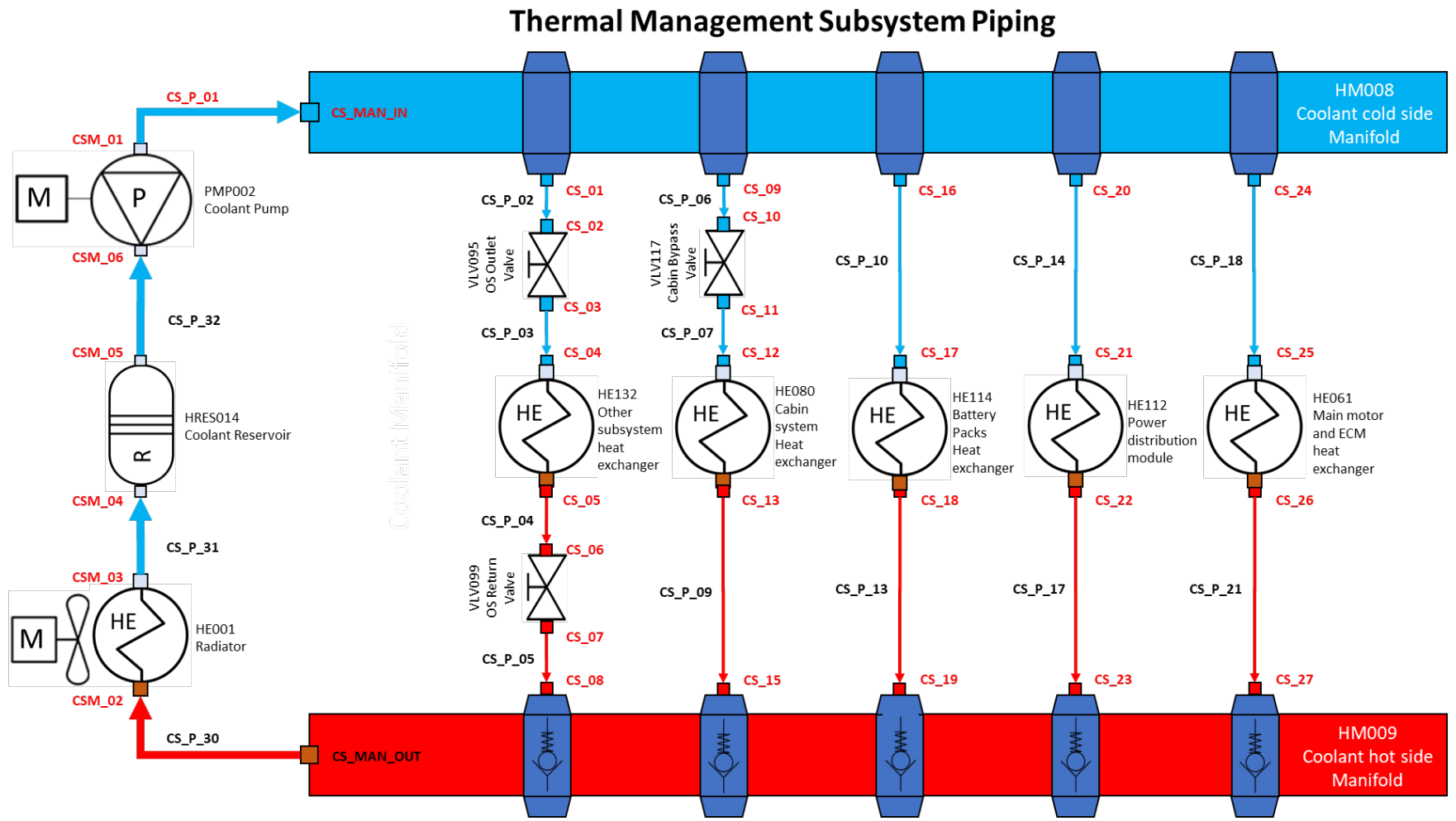
TECHNICAL APPROACH FOR REGISTRY STAGE 3

ARMY JA6268 DEMONSTRATION SYSTEM

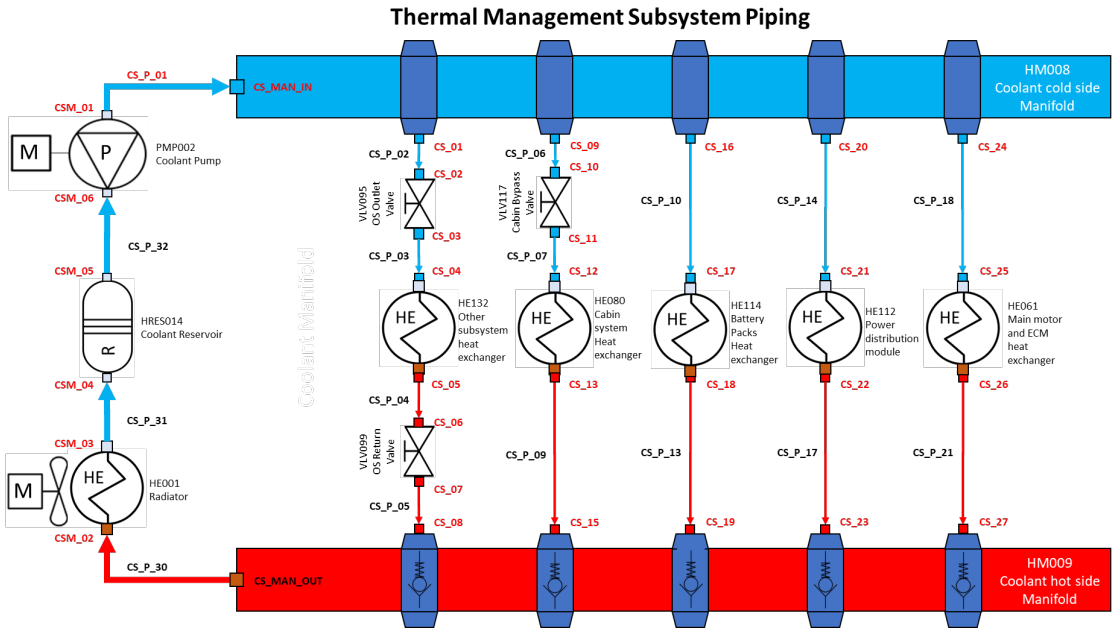


The objective of the program is to demonstrate how JA6268 can improve results and reduce cost of IVHM implementations.

THERMAL MANAGEMENT PIPING – TYPICAL SCHEMATIC



THERMAL MANAGEMENT PIPING – DATA EXTRACTION



Schematic NetList

ComponentInstanceCode_Source	ConnectorInstanceCode_Source	Pin_Source	ConnectionInstanceCode	Signal	MessageCode	ComponentInstanceCode_Destination	ConnectorInstanceCode_Destination
PMP002	CSM_01		CS_P_01			HM008	CS_MAN_IN
HM008	CS_01		CS_P_02			VLV095	CS_02
VLV095	CS_03		CS_P_03			HE132	CS_04
HE132	CS_05		CS_P_04			VLV099	CS_06
VLV099	CS_07		CS_P_05			HM009	CS_08
HM008	CS_09		CS_P_06			VLV117	CS_10
VLV117	CS_11		CS_P_07			HE080	CS_12
HE080	CS_13		CS_P_09			HM009	CS_15
HM008	CS_16		CS_P_10			HE114	CS_17
HE114	CS_18		CS_P_13			HM009	CS_19
HM008	CS_20		CS_P_14			HE112	CS_21
HE112	CS_22		CS_P_17			HM009	CS_23
HM008	CS_24		CS_P_18			HE061	CS_25
HE061	CS_26		CS_P_21			HM009	CS_27
HM009	CS_MAN_OUT		CS_P_30			HE001	CSM_02
HE001	CSM_03		CS_P_31			HRES014	CSM_04
HRES014	CSM_05		CS_P_32			PMP002	CSM_06

Assembly List / OEM Standard Data

Inherits From:	Assembly Name	Assembly Code	Assembly Abbreviation
GTHC008 Generic Heat Exchanger	Battery Heat Exchanger	HE114	CSBattHE
Generic Heat Exchanger	HVAC (Cabin Heat) Heat Exchanger	HE080	CSHVACHE
Generic Heat Exchanger	Main Motor Heat Exchanger	HE061	CSHVMotHE
Generic Heat Exchanger	Other System Heat Exchanger	HE132	CSOSHE
Generic Heat Exchanger	PDU Heat Exchanger	HE112	CSPDUHE
GHYC002 Generic Manifold	Coolant Cold Side Manifold	HM008	CSMnfld
GHYC003 Generic Manifold w Chk Valves	Coolant Hot Side Manifold	HM009	CSMnfld
GHYC001 Generic Pipe	Battery Packs Cold Side (Inlet) Pipe	CS_P_10	CSBattHExDscgPp
GHYC001 Generic Pipe	Battery Packs Return Hot Side (Dscg) Pipe	CS_P_13	CSBattHExInltPp
GHYC001 Generic Pipe	Cabin Bypass Valve Cold Side (Inlet) Pipe	CS_P_06	CSCabBPVlvInPp
GHYC001 Generic Pipe	Cabin Bypass Valve Cold Side Outlet (Dscg) Pipe	CS_P_07	CSCabBPVlvDscgPp
GHYC001 Generic Pipe	Coolant Pump Inlet Pipe	CS_P_32	CSPumpInPp
GHYC001 Generic Pipe	Coolant Pump Manifold Cold Side (Inlet) Pipe	CS_P_01	CSPumpMFldInPp
GHYC001 Generic Pipe	Coolant Pump Manifold Return Hot Side Pipe	CS_P_30	CSPumpDscgPp
GHYC001 Generic Pipe	Coolant Reservoir Clod Side (Inlet) Pipe	CS_P_31	CSRsvrInPp
GHYC001 Generic Pipe	Coolant Reservoir Output (Dscg)Pipe	CS_P_32	CSRsvrDscgPp
GHYC001 Generic Pipe	Main Motor Cold Side (Inlet) Pipe	CS_P_18	CSHVMotInPp
GHYC001 Generic Pipe	Main Motor Hot Side (Dscg) Pipe	CS_P_21	CSHVMotDscgPp
GHYC001 Generic Pipe	OS Outlet Valve Input Cold Side (Dscg) Pipe	CS_P_02	CSOSOutVlvInPp
GHYC001 Generic Pipe	OS Outlet Valve Output Cold Side (Inlet)Pipe	CS_P_03	CSOSOutVlvDscgPp
GHYC001 Generic Pipe	OS Return Valve Input Cold Side (Inlet) Pipe	CS_P_04	CSOSRtnVlvInPip
GHYC001 Generic Pipe	OS Return Valve Output Hot Side (Dscg) Pipe	CS_P_05	CSOSRtnVlvDscgPip
GHYC001 Generic Pipe	Power Distribution Module Cold Side (Inlet) Pipe	CS_P_14	CSPDUInPp
GHYC001 Generic Pipe	Power Distribution Module Return Hot Side (Dscg) Pipe	CS_P_17	CSPDUDscgPp
GHYC001 Generic Pipe	Radiator Cool Side (Inlet) Pipe	CS_P_30	CSRadInPp
GHYC001 Generic Pipe	Radiator Hot Side Pipe (Dscg)	CS_P_31	CSRadOutPp
GHYC013 Generic Reservoir	Coolant Reservoir	HRES014	CSRsvr
GHYC006 Generic Rotational Valve	Cabin Bypass Valve	VLV117	CSCabBPVlv
GHYC003 Generic Rotational Valve	Other System Outlet Valve	VLV095	CSOSOutVlv
GHYC005 Generic Rotational Valve	Other System Return Valve	VLV099	CSOSRtnVlv
STHC012 Standard Radiator	Radiator	HE001	CSRadHE
SVTH001 Standard Coolant Pump	Coolant Pump	PMP002	CSPump

BUILDING IVHM MODELS – STANDARD DATA

HRCS Templates

Generic

Generic Heat Exchanger

Generic Manifold

Generic Pipe

Generic Reservoir

Generic Rotational Valve

Commercial Truck

Industry Standard Cooling Fan

Industry Standard Radiator

Industry Standard Cooling Pump

Assembly List / OEM Standard Data

Inherits From:	Assembly Name	Assembly Code	Assembly Abbreviation
GTHC008 Generic Heat Exchanger	Battery Heat Exchanger	HE114	CSBattHE
GTHC008 Generic Heat Exchanger	HVAC (Cabin Heat) Heat Exchanger	HE080	CSHVACHE
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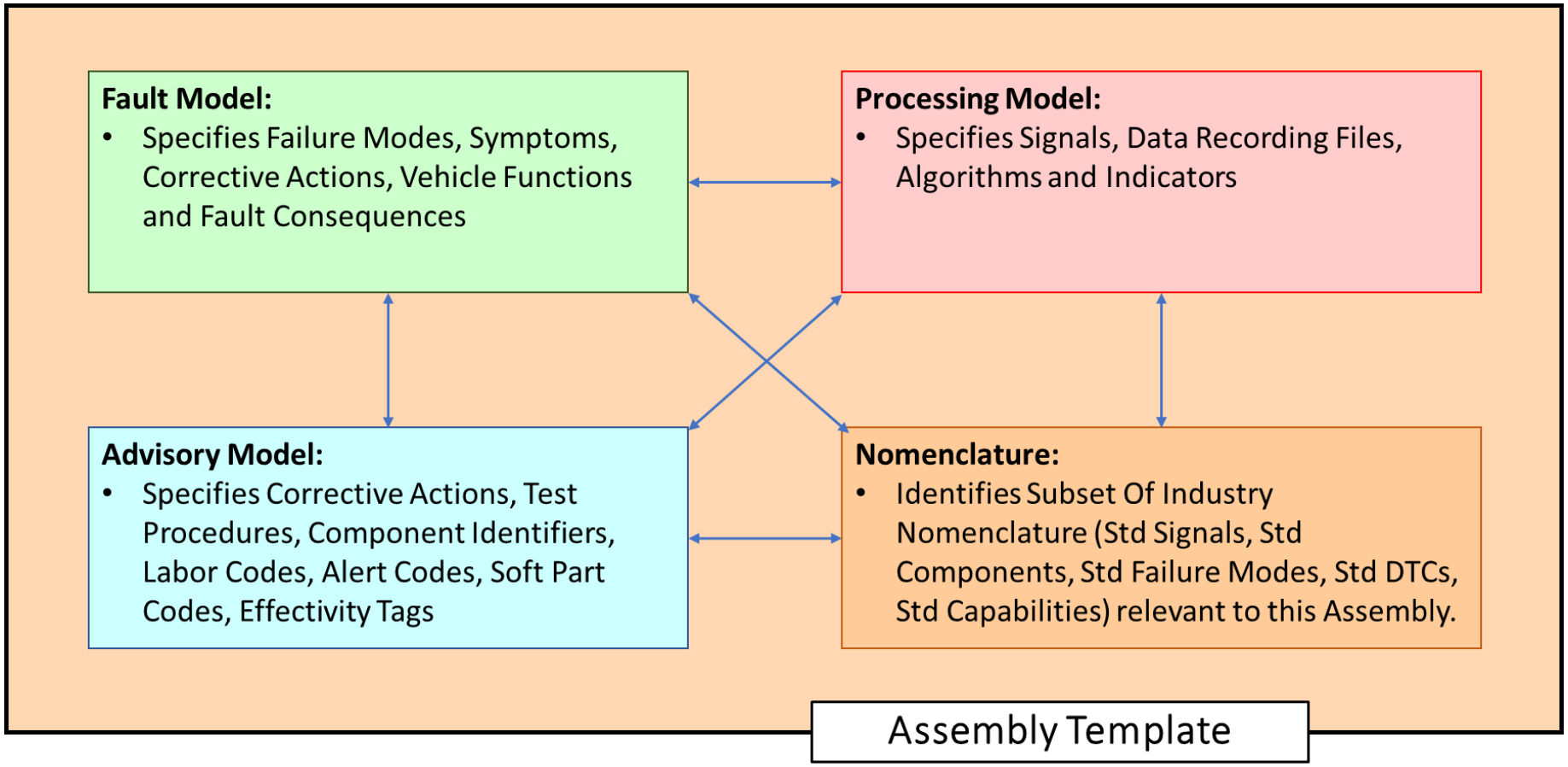
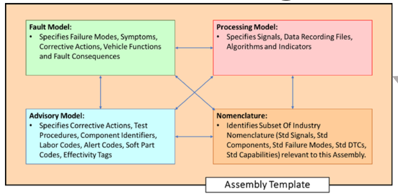
GTHC008 Generic Heat Exchanger	Other System Heat Exchanger	HE132	CSOSHE
GTHC008 Generic Heat Exchanger	PDU Heat Exchanger	HE112	CSPDUHE
GHYC002 Generic Manifold	Coolant Cold Side Manifold	HM008	CSMnfld
GHYC003 Generic Manifold w Chk Valves	Coolant Hot Side Manifold	HM009	CSMnfld
GHYC001 Generic Pipe	Battery Packs Cold Side (Inlet) Pipe	CS_P_10	CSBattHExDscgPp
GHYC001 Generic Pipe	Battery Packs Return Hot Side (Dscg) Pipe	CS_P_13	CSBattHExInltPp
GHYC001 Generic Pipe	Cabin Bypass Valve Cold Side (Inlet) Pipe	CS_P_06	CSCabBPVlvInPp
GHYC001 Generic Pipe	Cabin Bypass Valve Cold Side Outlet (Dscg) Pipe	CS_P_07	CSCabBPVlvDscgPp
GHYC001 Generic Pipe	Coolant Pump Inlet Pipe	CS_P_32	CSPumpInPp
GHYC001 Generic Pipe	Coolant Pump Manifold Cold Side (Inlet) Pipe	CS_P_01	CSPumpMFldInPp
GHYC001 Generic Pipe	Coolant Pump Manifold Return Hot Side Pipe	CS_P_30	CSPumpDscgPp
GHYC001 Generic Pipe	Coolant Reservoir Clod Side (Inlet) Pipe	CS_P_31	CSRsvrInPp
GHYC001 Generic Pipe	Coolant Reservoir Output (Dscg)Pipe	CS_P_32	CSRsvrDscgPp
GHYC001 Generic Pipe	Main Motor Cold Side (Inlet) Pipe	CS_P_18	CSHVMotInPp
GHYC001 Generic Pipe	Main Motor Hot Side (Dscg) Pipe	CS_P_21	CSHVMotDscgPp
GHYC001 Generic Pipe	OS Outlet Valve Input Cold Side (Dscg) Pipe	CS_P_02	CSOSOutVlvInPp
GHYC001 Generic Pipe	OS Outlet Valve Output Cold Side (Inlet)Pipe	CS_P_03	CSOSOutVlvDscgPp
GHYC001 Generic Pipe	OS Return Valve Input Cold Side (Inlet) Pipe	CS_P_04	CSOSRtnVlvInPip
GHYC001 Generic Pipe	OS Return Valve Output Hot Side (Dscg) Pipe	CS_P_05	CSOSRtnVlvDscgPip
GHYC001 Generic Pipe	Power Distribution Module Cold Side (Inlet) Pipe	CS_P_14	CSPDUInPp
GHYC001 Generic Pipe	Power Distribution Module Return Hot Side (Dscg) Pipe	CS_P_17	CSPDUDscgPp
GHYC001 Generic Pipe	Radiator Cool Side (Inlet) Pipe	CS_P_30	CSRadInPp
GHYC001 Generic Pipe	Radiator Hot Side Pipe (Dscg)	CS_P_31	CSRadOutPp
GHYC013 Generic Reservoir	Coolant Reservoir	HRES014	CSRsvr
GHYC006 Generic Rotational Valve	Cabin Bypass Valve	VLV117	CSCabBPVlv
GHYC003 Generic Rotational Valve	Other System Outlet Valve	VLV095	CSOSOutVlv
GHYC005 Generic Rotational Valve	Other System Return Valve	VLV099	CSOSRtnVlv
STHC012 Standard Radiator	Radiator	HE001	CSRadHE
SVTH001 Standard Coolant Pump	Coolant Pump	PMP002	CSPump

TEMPLATES PROVIDE VALUABLE DATA FOR EACH COMPONENT

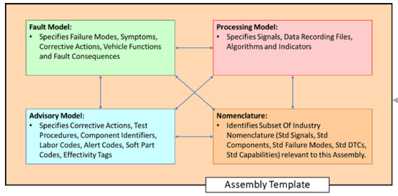


THERMAL MANAGEMENT PIPING – COMBINED CONTENT

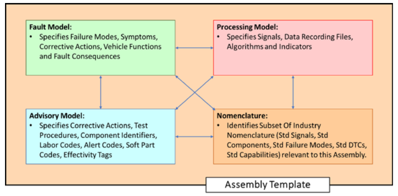
Standard Cooling Pump

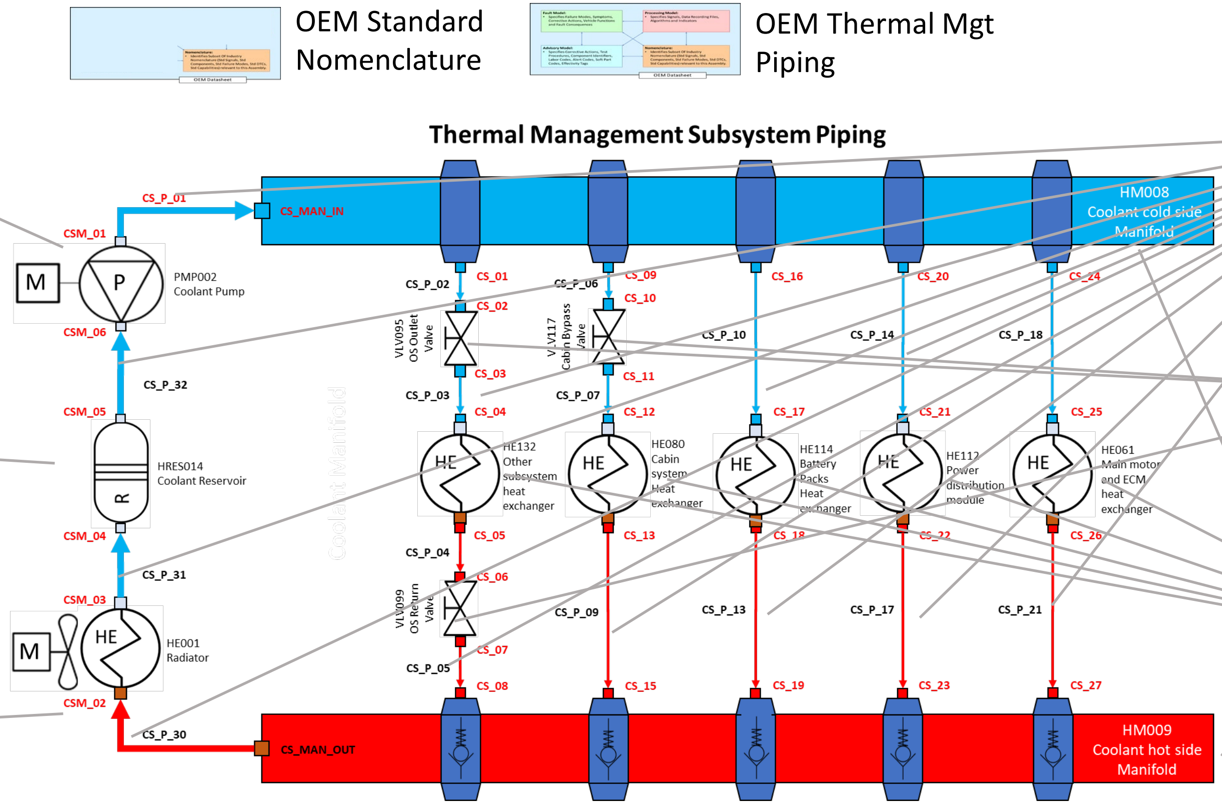


Standard Cooling Reservoir

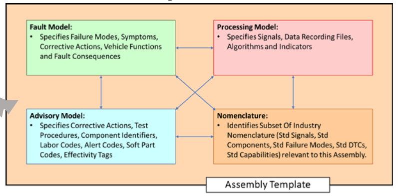


Standard Radiator

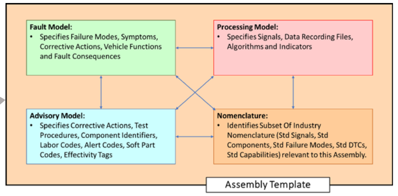




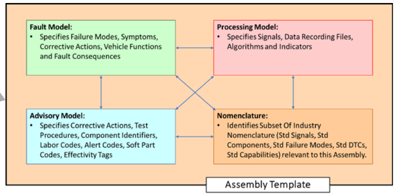
Generic Pipe



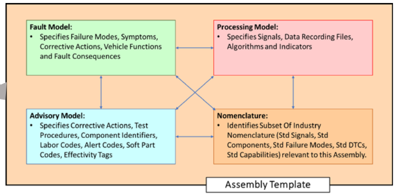
Generic Valve



Generic Heat Exchanger



Generic Manifold



Generic Templates: Include Failure Modes, Symptoms Interfaces, Signals, Data Recordings, Algorithms and Symptoms.

Standard Templates: Add DTC's, Standard Signals, Operational Effects, Operator Indicators

BUILDING FAULT MODELS

HRCS Templates

Generic

Generic Heat Exchanger

Generic Manifold

Generic Pipe

Generic Reservoir

Generic Rotational Valve

Commercial Truck

Industry Standard Cooling Fan

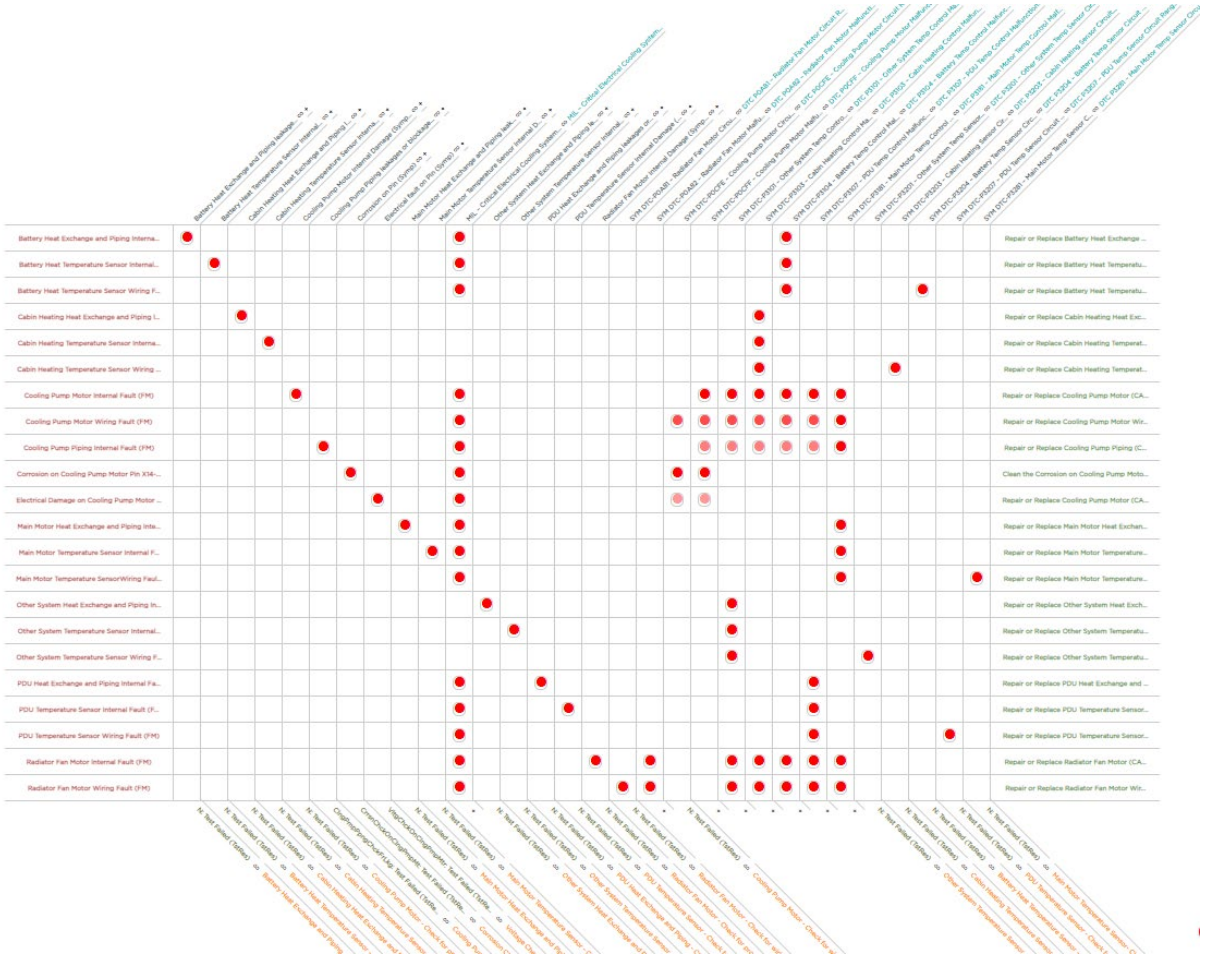
Industry Standard Radiator

Industry Standard Cooling Pump

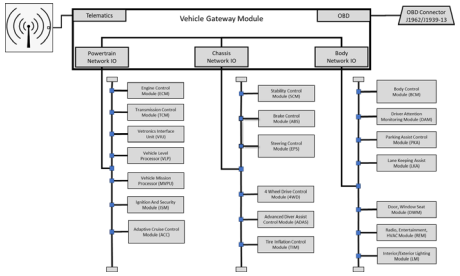
OEM Specifications

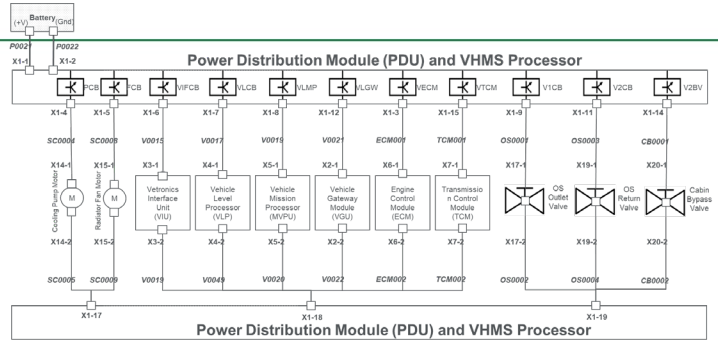
OEM Standard Nomenclature

OEM Thermal Mgt Piping



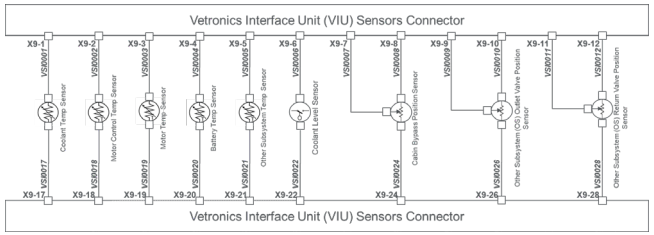
BUILDING IVHM MODELS – SYSTEM DATA

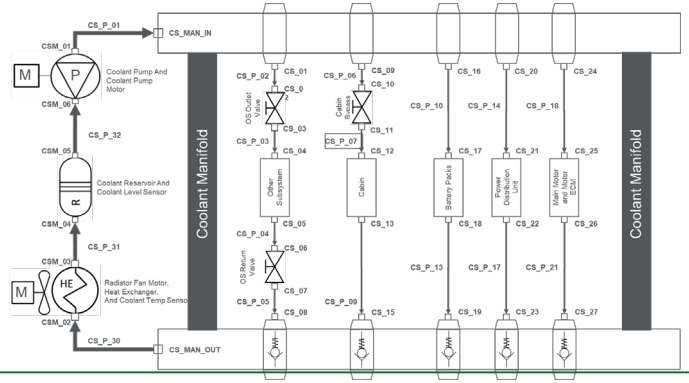


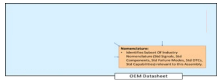


Heat Exchange Signal Flow

			Signal Out							
			Hydraulic Inlet			Thermal Interface		Hydraulic Discharge		
		Signal In	Temperature	Pressure	Flow	Temperature	Heat Exchange Rate	Temperature	Pressure	Flow
Signal In	Hydraulic Inlet	Temperature	X					X		
		Pressure		X	X		X	X	X	X
		Flow			X		X		X	X
	Thermal Interface	Temperature				X		X		
		Heat Exchange Rate					X	X		
	Hydraulic Discharge	Temperature						X		
		Pressure			X		X	X	X	
		Flow		X			X	X		X







OEM Standard Nomenclature

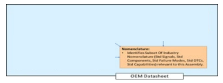
OEM Thermal Mgt Piping

OEM Vehicle X Comm Topology

OEM Vehicle X Thermal Mgt Electrical Schematics

OEM Vehicle X Power / Ground Schematics

Algorithm Processing


OEM Standard Nomenclature


OEM Thermal Mgt Piping

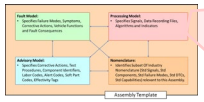

OEM Vehicle X Comm Topology


OEM Vehicle X Thermal Mgt Electrical Schematics


OEM Vehicle X Power / Ground Schematics

System Files Translate Component Signals to System Signals which are Mapped to Standard Signals

Standard Cooling Pump

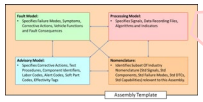


Regimes
- Pump Off
- Pump Start
- Pump Steady
- Pump Stop

Data Recordings:
- Pump Start Fluid Dynamics
- Pump Start Electrical Dynamics

Algorithms:
- Time to Prime
- Pump Motor Start Torque and Speed
- Pump Motor Winding Health

Generic Valve

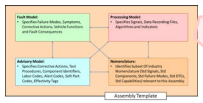


Regimes
- Valve Closed
- Valve Opening
- Valve Open
- Valve Closing

Data Recordings:
- Valve Opening
- Valve Closing

Algorithms:
- Valve Actuation Performance

Generic Solid State Circuit Breaker



Regimes
- Breaker Closed
- Breaker Opening
- Breaker Open
- Breaker Closing

Data Recordings:
- Breaker Opening
- Breaker Closing

Algorithms:
- Breaker Actuation Performance

Component Files Define Regimes, Data Recordings, Algorithms and Indicators

Data Recording Files
- Pump Start Fluid Dynamics
- Pump Start Electrical Dynamics
- Valve Actuation Fluid Dynamics
- Solid State Relay Transient Recording

Regimes
- Pump Start
- Valve Actuation
- Breaker Closing

Algorithms
- Time to Prime
- Pump Motor Start Torque and Speed
- Pump Motor Winding Health
- Valve Actuation Performance
- Valve Electrical Performance

Indicators (Condition, Health, Predictive, Usage)
- Time to Prime
- Pump Start Fluid Dynamics
- Pump Start Electrical Dynamic
- Valve Actuation Performance
- Valve Electrical Performance

ENABLED CAPABILITIES

Templates provide substantial details regarding component failure modes, symptoms, signals, operation impact, data recordings, algorithms, indicators and reported DTCs / Fault Codes.

Method allows templates to be linked to other design artifacts:

- Schematics
- Topology Diagrams
- Message Routing Tables
- Signal Flow Diagrams
- FMEAs
- Fault Trees

Once templates and design data are linked, info can be used by:

- Vehicle Analytics
- Prognostics
- Diagnostics
- Quality / Fleet Analytics
- Machine Learning

Note: Project Includes:

- *Serial Communications*
- *Comm Topology*
- *Power and Ground*
- *Signal Flow*
- *Functional Dependency*

Resulting in appx 20 Generic and Std Templates and 10 Project Specific Datasheets.

HEALTH-READY COMPONENTS AND SYSTEMS