Zero Emissions Vehicle (ZEV) Diagnostic and Repair Standardization The “ZEVDRS” and J1979-3 Update

Andrew Zettel

andrew.zettel@gm.com

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Background

Introducing the concept of a ZEVDRS:

Zero Emissions Vehicle Diagnostics and Repair Standardization

OEMs are recurringly discussing the service content required for a ZEV to be considered acceptable in the global marketplace

It is not in the interest of the market to diverge into multiple industry standards:

Ambiguity results in global regulators designing their own standards (i.e., CARB ACC2 Regulation)

In this presentation a design is proposed that includes already validated standards from ISO and SAE.*

Introduction: Terminology and Design Standards

Terminology

Emissions Related
OBD =
Diagnosing Control Systems on a Vehicle with Emissions

PHEV/
OVC-HEV

Fuel Cell

OBD =
Diagnosing Control Systems on a ZEV Vehicle (safety, service, etc.)

BEV/PEV

Design Guidance

Emissions/OBD Regulations
(Which include J1979-2 OBDonUDS)

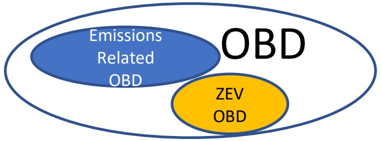
ZEVDRS
Which include
J1979-3
(ZEVonUDS)

ZEVDRS = ZEV Diagnostic and Repair Standardization

Reappropriate the term '*OBD*' back to the general meaning of "*in vehicle diagnostics*"

Proposal:

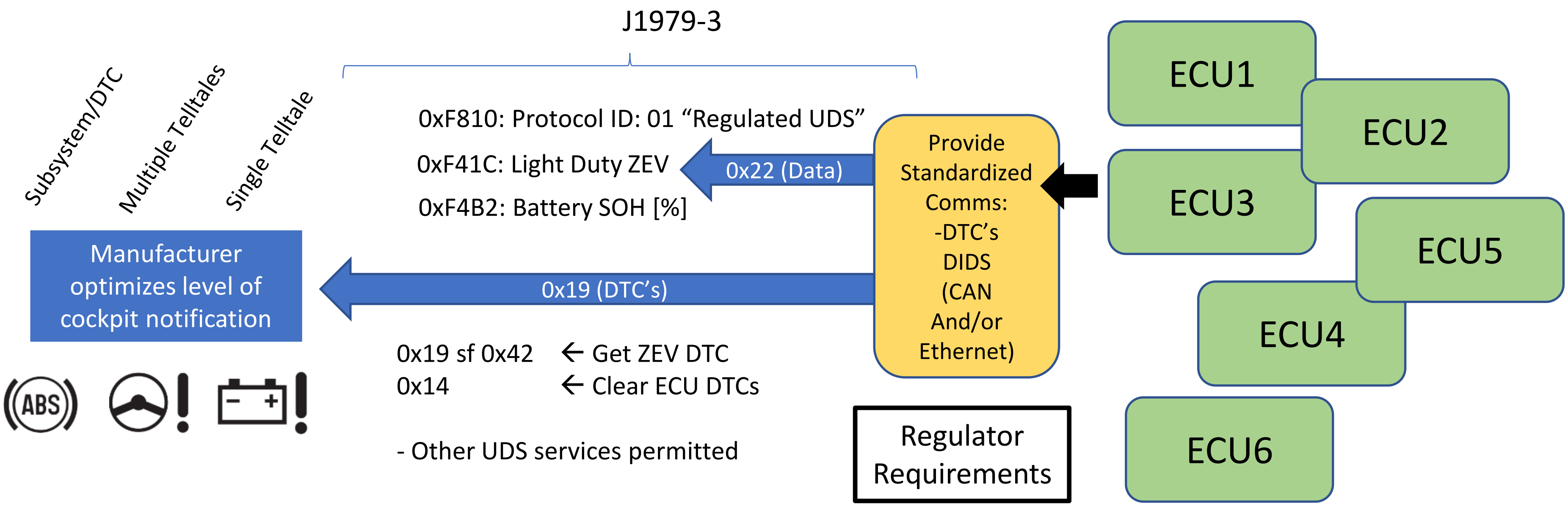
As we move toward an all-electric future, On Board Diagnostics will continue to exist in ground transportation. Proposal: enforce the qualifier of "Emissions" *before* OBD. (when applicable)



Overview of ZEVDRS Standardization (J1979-3)

- Focus is on Independent Data Support and Repair (ISO 14229 Reserved DID Range)
  - Battery aging
- Standardized DTC's (J2012)
  - Fault Isolation to smallest electronic repairable component
    - Customers can make informed repair choices: what needs repair and where to repair (at home, independent repair, OEM dealership)
- Standardized Connector (J1962 – Already allows for CAN and Ethernet)
- Standardized Protocol (elements of ISO 14229 (UDS)) to allow low-cost customer and vehicle communications (ensure no difference in communication method between propulsion and other vehicle ECU's for service)
  - J1979-3 (in draft provides a minimum number of required diag services)
    - Propulsion system functional response requirements
    - ZEV protocol discovery using traditional Service 0x22 – 0xF810 → 0xF41C (HD ZEV, etc.)
      - Aligns nicely with existing conventional vehicle scan tool validation framework
      - However! The vehicle may only respond to 0xF810 over Ethernet OR CAN.
        - It can still support diagnostics over both buses, but per ACC2 must only acknowledge regulated ZEV over one bus or the other.

Minimize disturbance to mature off the shelf UDS control system = Fastest time to market, robustness, lowest cost for customers



As internal combustion vehicles phase out, also phase out referencing emissions requirements and focus investment on ISO-14229 / ISO 13400 (CAN and Ethernet). J1979-3 Provides Elaboration on the minimum quantity of services and the standardized data is expected (J1979DA and J2012)

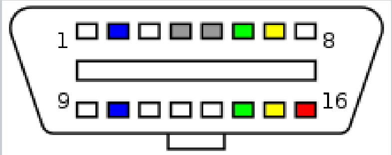
J1962 Connector : How to connect to a vehicle in MY26+

J1979-3 transitions manufacturers to support 3 possible (already validated) configurations for supporting CARB ACC2 ZEV Standardization.

- J2534-2

w/ Direct Connect Ethernet Option

A. CAN (pins 6,14)
B. Ethernet Option 1 (pins 3,11,12,13) +8
C. Ethernet Option 2 (pins 1, 9, 12, 13)+8



Female OBD-II connector pinout - front view

As of 2QTR =2020: Many tools already support this framework using J2534-2 with 0404 API.

Managing the Standardized Data:

J1979 Committee assists in providing a column to highlight the source of the requirements for these new DIDs (in addition to ZEVDRS voluntary supported DIDs):

For example:

1. Advanced Clean Cars 2
2. UN-EVE GTR, etc.
3. EU Certification Requirements

	A	B	C	D	H	I	J	K	Q		
1	SAE J1979/ ISO 15031-5 ITID (InfoType ID)	ISO 27145-2/J1979-2 ITID	Description	Scaling/bit	1968.2 Referen	1971.1 Referen	ZEP	CARB Standardization 1968.5	UNECE GTR Part 1	ZEV Industry Recommended Support	Japan ZEV
579	0x8E	0xF890	Average battery temperature while vehicle Off (Recent)	1 Byte 1°C with -40°C offset Min Value: -40 C Max Value: 215 C				1962.5(c)(4)(D)1.r		X	
580	0x8E	0xF890	Average battery temperature while vehicle Off (Lifetime)	1 Byte 1°C with -40°C offset Min Value: -40 C Max Value: 215 C				1962.5(c)(4)(D)1.r		X	
581			Time at Temperature during PSA								
582	0x8E	0xF891	Battery Pack Time at Temperature during PSA < Range 1 (Lifetime)	4 bytes 1 sec per bit Min Value: 0 sec Max Value: 4,294,967,295 sec						X	
583	0x8E	0xF88F	Battery Pack Time at Temperature during PSA within >=Range 1 < Range 2 (Lifetime)	4 bytes 1 sec per bit Min Value: 0 sec Max Value: 4,294,967,295 sec						X	
584	0x8E	0xF88F	Battery Pack Time at Temperature during PSA within >=Range 2 < Range 3 (Lifetime)	4 bytes 1 sec per bit Min Value: 0 sec Max Value: 4,294,967,295 sec						X	
			Battery Pack Time at Temperature during PSA within >=Range 3	4 bytes 1 sec per bit Min Value: 0 sec							

ZEV Supplemental Columns provide any regulatory requirements that require standardized data:

Battery Warranty:

- CARB requires dashboard display of Battery State of Health (0-100%)
- CARB requires the battery warranty be tied to the SOH display

Battery Warranty. The vehicle manufacturer of each battery electric vehicle and plug-in hybrid electric vehicle shall warrant to the ultimate purchaser and each subsequent purchaser that the vehicle's battery is free from defects in materials and workmanship which cause the battery state of health to deteriorate to less than:

70% for a warranty period of eight years or 100,000 miles, whichever first occurs, for 2026 through 2030 model years, and

75% for a warranty period of eight years or 100,000 miles, whichever first occurs, for 2031 and subsequent model years.

Few similar situations exist in the automotive industry where the glideslope towards the possible warranty repair of a component under warranty is so visible to a customer.

For example: a battery that is perfectly acceptable to a given customer that hits ***74.9%*** SOH could demand a warranty replacement of the battery pack.

ie., a 600km range EV new that still supports 440 km at year 7 would be required to be replaced under the new regulations.

Battery Durability:

- CARB requires a minimum propulsion durability throughout useful life. (measured in range)
- CARB provisions for testing of the fleet to ensure durability is acceptable.

Battery Durability.

2026 through 2029 the durability tests indicate that more than **30 percent** of the vehicles in the test sample group fall below **65 percent** of the certified all-electric range.
2030 through 2032, the results of the durability tests indicate that more than **50 percent** of the vehicles in the test sample group fall below **75 percent** of the certified all-electric range.
2033 and subsequent model year, the results of the durability tests indicate that more than 50 percent of the vehicles in the test sample group fall below 80 percent of the certified all-electric range

SOH Parameter Accuracy: (protecting for over-reporting of SOH)

- CARB requires an accurate calculation of Battery State of Health (SOH).
- CARB provisions for testing of the fleet to ensure SOH calculation is accurate.

SOH Accuracy:

The results of battery SOH parameter accuracy testing indicate that more than 30 percent of the vehicles in the test sample group report an SOH that:

2026 through 2028 is more than **8 percentage points** higher than the SOH value corresponding to the measured usable battery energy
2029 and subsequent model years, is more than **5 percentage points** higher than the SOH value corresponding to the measured usable battery energy

State of Health (SOH) Calculation Primer:

- State of Health transparency is important for mass adoption and confidence of used ZEV's.
- On a 10+ year old vehicle, the value of the vehicle will be dominated by the batteries remaining storage capability. (*or assumptions about its remaining capacity*)
- Even with a displayed value as simple as a 0-100%, it still has some very complicated use-cases that need to be integrated into the calculation.
- SOH includes both a numerator and denominator, the measured capacity divided by the certification capacity in kWh. DID's are also stored for both, in addition to the final ratio that is displayed to a customer and service technician as a DID.

Today

Recent Calculated Capacity
[0xF4D0 (K,L,M)]

J1634

Certified Capacity
[0xF4D0 (H,I,J)]

SOH

87.2 %

State of Health
SOH %
[0xF4B2(A)]

** If reserve capacity is released while vehicle is in-use, the quantity of released energy shall be added to the denominator*

Albeit this common calculation across all manufacturers will dramatically improve the used EV landscape, some questions remain:

State of Health Supporting Information:

SOH

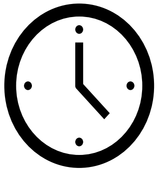
87.2 %

How recent is this value?

- Because of the profound financial impact of the SOH on sellers and purchasers alike, the recentness of an SOH is critical.
- Furthermore, standardization requirements include details to ensure integrity of the calculation.

A second parameter is required to be provided on the dashboard to ensure customers are provided with a sense of when the last capacity calculation was made on the vehicle:

Distance Since State of Health Last Updated



Distance since SOH updated

0xF4D0(B,C)

360 km

Emphasizing the importance of the credibility of an SOH calculation:

SOH

87.2 %

Distance Since Last SOH Update

360 km

- CARB will enforce the accuracy of the SOH calculation (accuracy requirement stringency depends on model year)
- Customers will be directed to utilize the SOH indicator as their primary determination for battery replacement under warranty.
- On used vehicles, customers will use battery SOH to interpolate the label range to estimate if a used EV meets their needs.
  - New Vehicle = 500 km label range,
  - Used Vehicle @80% SOH = 400 km vehicle range
- Because the SOH and Distance Since Last SOH update values will have such high visibility and impact to customer (and manufacturer), they must be coherent under all foreseeable use-cases.

Battery State Estimation System Architecture (Simplified)

Voltage

Current

Temperature

Time and Correct Conditions (such as %DOD)

Battery State Estimation

SOH

87.2 %

Distance Since Last SOH Update

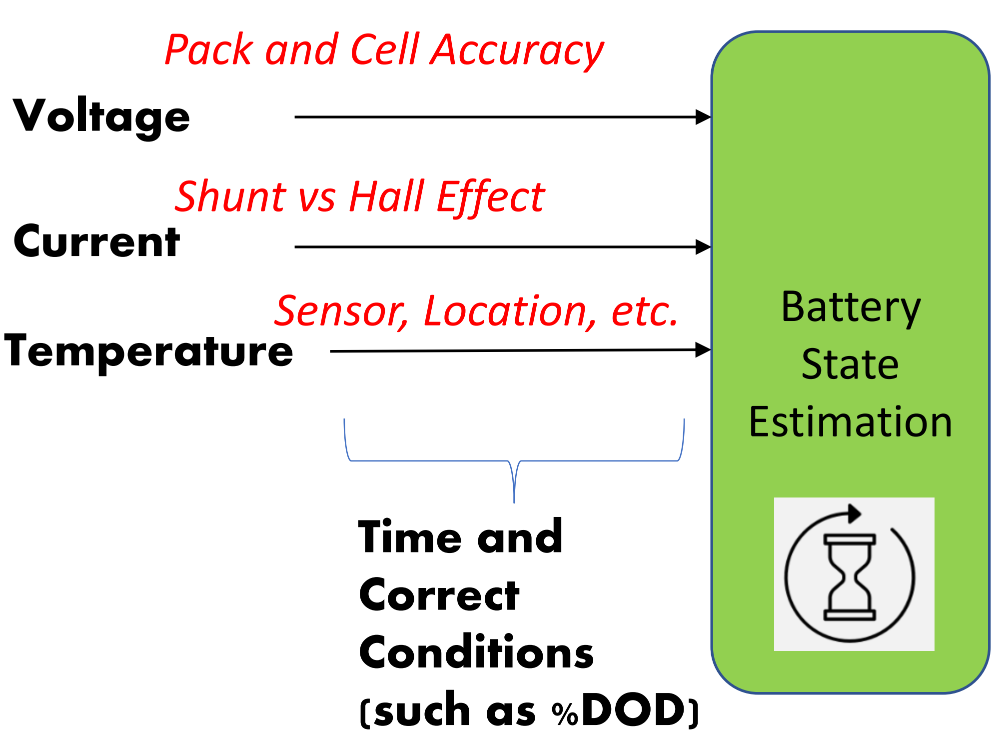
360 km

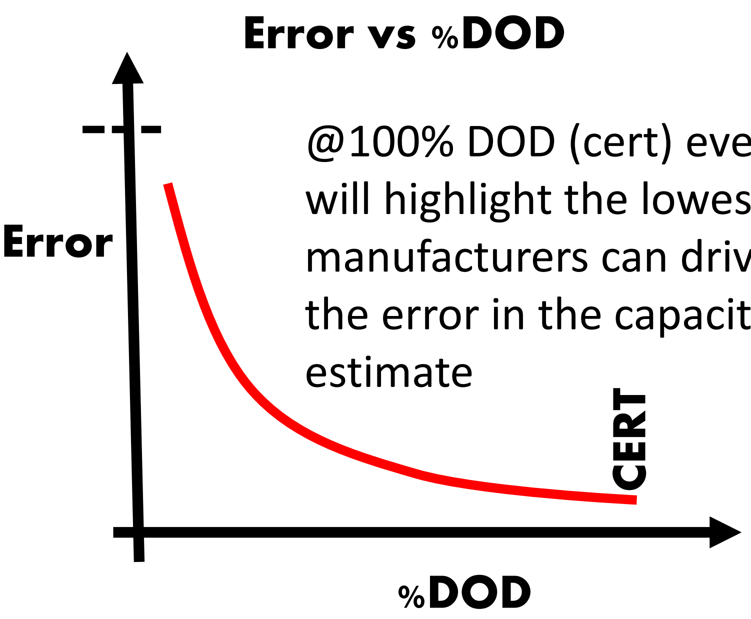
a) Dashboard Display and b) Scan Tool

During regular driving, this framework is suitable, however, some individual use cases require some additional complexity.

%DOD = Precent Depth of Discharge

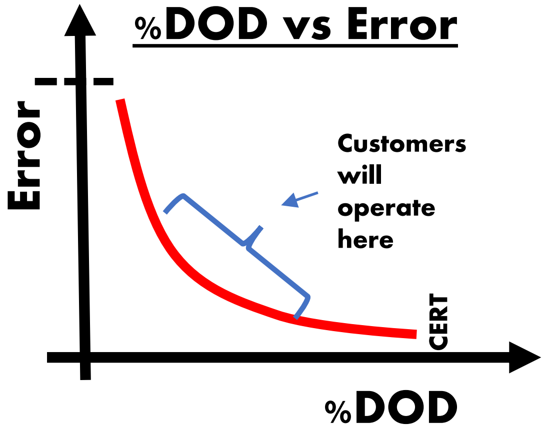
Battery State Estimation System Architecture : Accuracy Concerns

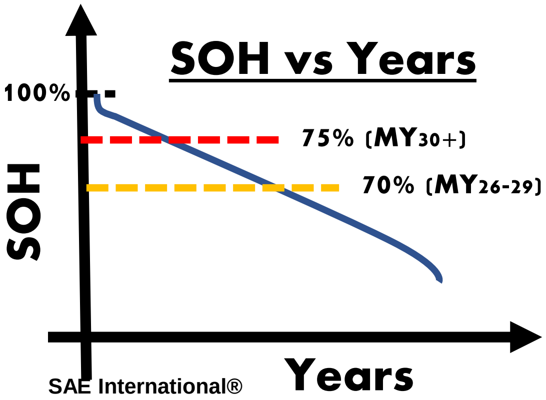




@100% DOD (cert) events will highlight the lowest manufacturers can drive the error in the capacity estimate

Battery State Estimation System Architecture : Accuracy Concerns

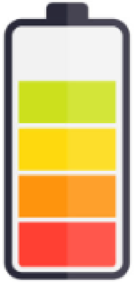




Some Commentary on SOH error:

1. For 100% DOD Cycles (ie., cert cycles), Sensor technology and variation over time will dominate how low errors can be driven. CARB demands 8% followed by 5% in MY29.
2. For actual customer use, the error will be higher. i.e. Customers will almost never fully discharge their battery. Manufacturers will need to tradeoff frequency of update with tolerable errors for their customers. Educating customers on how to operate their vehicle to get an accurate update will be important. (before buying a vehicle ensure the battery is cycled).
3. The CARB requirement is only for overestimation errors. Therefore, the system will tend to be conservative in nature while not risking underestimating and hitting the warranty thresholds.

State of Health Supporting Information: Use-cases for consideration



Considerations for Capacity Update:

A. Dealership arrival and expedient delivery to a customer.
B. Dealership arrival and use as a demonstrator vehicle. (ie., ~ 6 months)
C. Dealership arrival and “lot rot” vehicle sitting without charging/driving.
D. Customer Case 1: Short Trips, frequent charging, charge Termination @80%.
E. Customer Case 2: Road Trip, deep cycle charging, charge termination @100%.
F. Customer Case 3: Non good-faith vehicle sale: obscuring SOH by delaying SOH update to avoid transparency around actual SOH.
G. Customer Case 4: Vehicle used as remote generator without any driving.
H. Service Case 1: Sectional replacement.
I. Service Case 2: Full pack replacement.
J. Service Case 3: ECU replacement.

State of Health Supporting Information – Capacity update framework:

A. Dealership arrival and expedient delivery to a customer:

Vehicles are typically transported with <50% state of charge to the dealership/customer.

1. Battery Assembly

SOC: 46%

2. Vehicle Integration

Vehicle has limited time to assess the state of the battery capacity

3. Vehicle Shipment to Customer

SOC: 45%

SOH:  **or** 100%[1]

Distance Since Last SOH Update: 

SOC: 85%-100%

40-55 %DOD

SOH: **100%**

Distance Since Last SOH Update: **0 km**

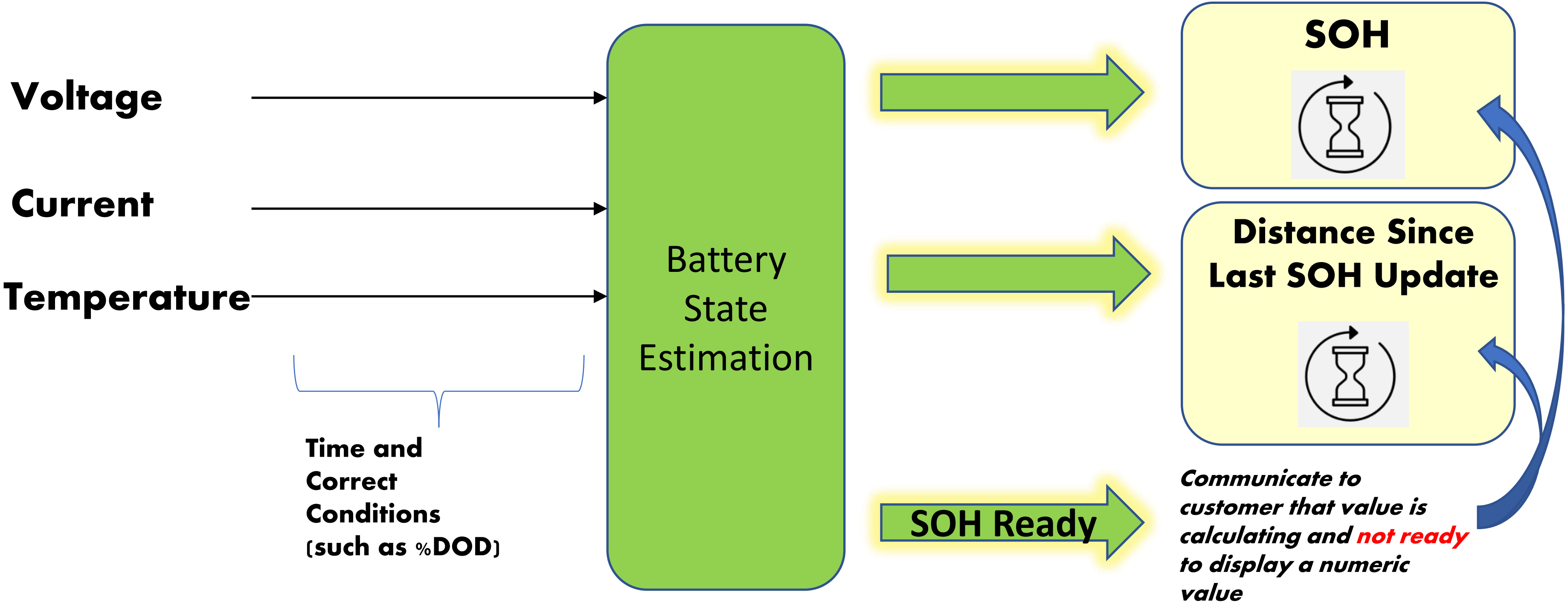
4. First Full Charge:

a) Dealership or

b) Customer

1. CARB allows initializing of SOH to 100% only for newly manufactured vehicles.

Battery State Estimation System Architecture Solution: Not Ready / Calculating



SOH Ready/Not-Ready: DID only,
- Used for times when confidence is low in SOH value due to long resting time, ECU replacements, etc.

a) Dashboard Display and
b) Scan Tool
OEM's have flexibility w/ Icon, blank field, etc.

Introduction of Standardization Data to Prepare for CARB Battery Durability Enforcement

- As mentioned earlier, CARB has developed powertrain durability requirements.
- J1979 ZEV Task Force is developing standardized on-board vehicle data that should allow for exclusion of vehicles from durability requirements for those experiencing extreme conditions/usage.
- These items will be discussed in the panel session.
  - Depth of Discharge Trackers
  - Temperature Trackers
  - Time at State of Charge Trackers
- The task force is also working to amalgamate the requirements from the UN and European Union discussions.

Summary

In order to provide the best full life-cycle experience for ZEV customers, standardization of the areas of diagnostic communication and repair is essential.   Such a vision broadens customer options for repair and service and will reduce proprietary functions (with limited support in the marketplace).

Using an ISO / UDS foundation allows both manufacturers and tool makers to scale from existing solutions as opposed to beginning from scratch.

State of Health was discussed and is one of the most important dashboard values ever put in front a customer. The use of a “Ready” flag is provided as an option to ensure that only “verified” SOH values are put in front of a customer.

Manufacturers will support DIDs that allow them to exclude vehicles that have experienced events that are out of the ordinary.   Industry will continue to work with the regulators to determine how to quantifiably make the exclusion requests.

J1979-3 Publishing Targeted Fall 2022.
To access the documents referenced in this presentation:

Visit:

https://www.iso.org/store.html/

https://www.sae.org/standards

Contact Info

Thank you!

Andrew Zettel

Technical Fellow – Electrification Systems Architect, OBD

General Motors

andrew.zettel@gm.com

Supporting Slides

DOIP IS SIMPLY AN ETHERNET WRAPPER AROUND UDS MESSAGES

- If an ECU supports UDS messages, DOIP simply transports them back and forth to a tool

				DOIP Payload			
1 Byte	1 Byte	2 Bytes	4 Bytes	2 Bytes	2 Bytes	1 Byte	n Bytes
Ver	~Ver	Type	Length	Source	Target	Ack code	UDS Message
0x02	0xFD	0x8002	…	0x0E00	0xE000	0x00	0x22 F8 10

ZEVonUDS standardizes the source and target address to align with WWHOBD

Nothing changes with the actual UDS implementation

SPECIFICS RELATED TO J1979-3

- Formalizing the use of ISO 27145 Functional DOIP and Source Addresses:

Addressing message type	Target address (TA)	Source address (SA)	Description
Functional request	$E000_{16}$	$0E00_{16}$	SA = ZEV external test equipment TA = all ZEV-relevant server(s)/ECU(s)
Physical request	$YYXX_{16}$ [a]	$0E00_{16}$	SA = ZEV external test equipment TA = one ZEV-relevant server/ECU
Physical response	$0E00_{16}$	$YYXX_{16}$ [a]	SA = one ZEV-relevant server/ECU TA = ZEV external test equipment
[a] $YYXX_{16}$ range from $E001_{16}$ to $E3FF_{16}$			

SpeCIFICS RELATED TO J1979-3

- Formalizing the Routing Activation for ZEV ECU's ->

Value	Description	Required Action	Support
00_{16}	Default	None	Mandatory
01_{16}	Diagnostic communication required for regulated ZEV Propulsion Systems	None	**Mandatory**
02_{16}-DF_{16}	ISO/SAE Reserved		
$E0_{16}$	Central Security	VM-specific	Optional
$E1_{16}$ to FF_{16}	Available for additional VM-Specific Use	VM-specific	Mandatory