INL/MIS-25-85211-Revision-0

ChargeX Consortium - Vehicle-Grid Integration Council Presentation

June 2025

Changing the World's Energy Future

Casey W Quinn

Idaho National Laboratory

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Idaho National Laboratory
Idaho Falls, Idaho 83415

http://www.inl.gov

Prepared for the
U.S. Department of Energy
Under DOE Idaho Operations Office
Contract DE-AC07-05ID14517

ChargeX Consortium

Vehicle-Grid Integration Council Presentation

CHARGEX consortium

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Argonne NATIONAL LABORATORY

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NREL Transforming ENERGY

June 4, 2025

INL/MIS-25-85211

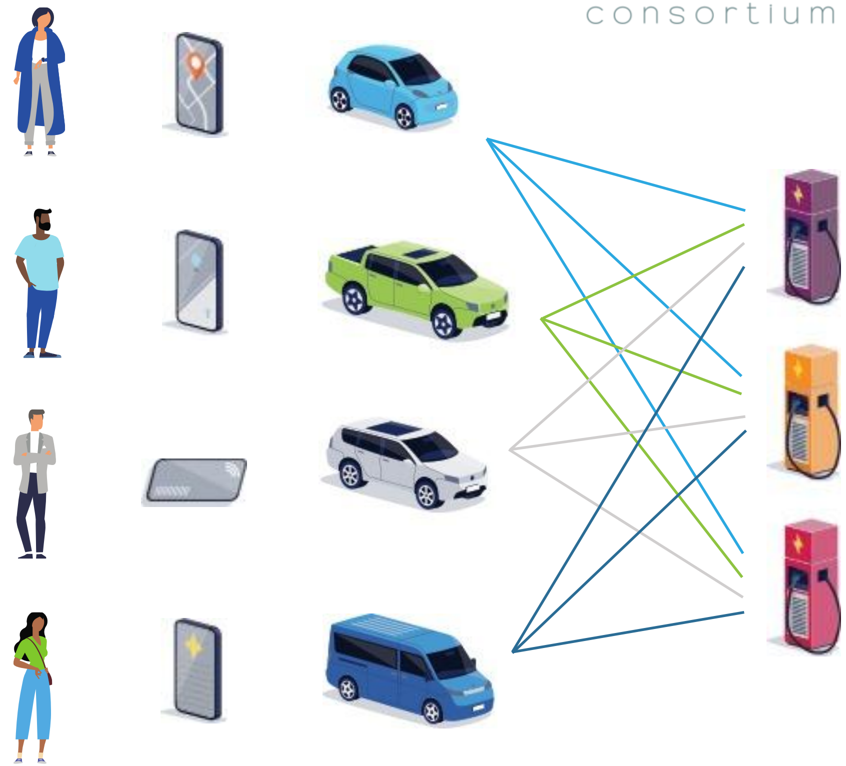
Any Driver, Any EV, Any Charger

Mission

Bring together EV charging industry members, national laboratories, consumer advocates, and other stakeholders to measure and significantly improve public charging reliability and usability in North America **by June 2025**

Scope

Focus on complex issues that require multi-stakeholder collaboration and national lab support to solve and simplify



FIRST TIME,
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Executive Summary

- ChargeX Consortium will have aided industry to improve the driver EV public charging experience
- Research priorities were directed by industry participants
- Collaborated, shaped and standardized steps and processes of EV charging with 90+ company participants since 2023
- Accomplished handover efforts to industry for implementation
- Widened the consortium’s scope to include VGI tasks to elevate the charging experience

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Participants (90 as of 12/31/2024)

Charger Manufacturers and Suppliers	ABB e-Mobility, Amphenol, Autel, Bosch, BTC Power, ChargeTronix, Dover Fueling Solutions, Eaton, Evalucon, Heliox, IoTecha, Qualcomm, Siemens, SK Signet,Tritium, Wallbox
Customer-Facing Charging Station Operators	Apple Green Electric, Blink Charging, bp pulse, ChargePoint, Electrify America, EVgo, FLO, Francis Energy, HeyCharge, KIGT, Koulomb, Lynkwell, NovaCHARGE, NYPA, Rove, SWTCH, Xeal Energy
Charging Network and Software Providers	ampcontrol, AMPECO, ampUp, ChargeMate, Driivz, EV Connect, Noodoe, PIONIX, Switch
Auto Manufacturers	American Honda, BMW of North America, Ford Motor Company, General Motors, Lucid, Mercedes-Benz North America, Rivian, Stellantis, Subaru of America, Tesla, Toyota Motor North America, VinFast Auto, Volvo Car USA
3rd-Party Roaming Hubs and eMSPs	AeonCharge, Bluedot, ChargeHub, Emobi, Hubject
Field Services and Analytics Firms	Atlas Public Policy, ChargerHelp!, Energetics, EVSession, Field Advantage, ReliON, Uptime Charger, WattsUp
Consumer Advocates	Cool the Earth, Consumer Reports, EVinfo, J.D. Power, Plug In America
Fleets	Hertz
Payment Industry Stakeholders	Nayax, Payter, WEX
Standards Organizations and Technology Alliances	CharIN North America, COVESA, NEMA, Open Charge Alliance, SAE Sustainable Mobility Solutions
Research Organizations and Universities	American Center for Mobility, EPRI, Transportation Energy Institute, University of California, Davis; University of Washington
State Agencies	California Air Resources Board, California Energy Commission, Caltrans

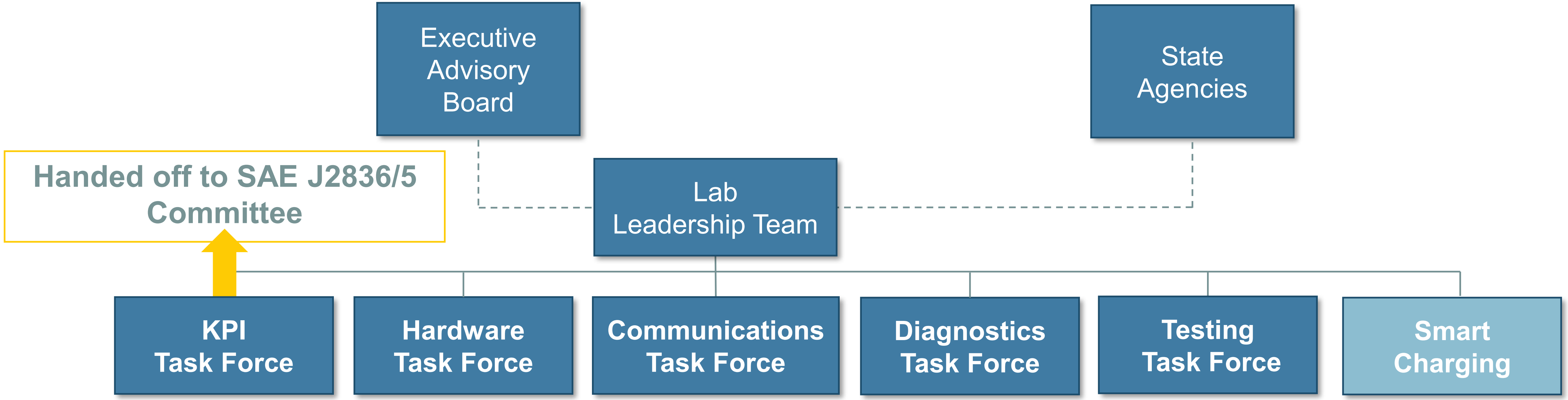
Scope of Work

Defining the Charging Experience	Reliability/Usability Triage	Solutions for Scaling Reliability
• Define KPIs • Develop and verify implementation instructions	Create fixes for: • Payment and user interface • Communication • Hardware	Improve: • Diagnostics • Interoperability testing methods

Outcomes

- Labs produce recommended practices, prototype tools
- Industry adopts practices and tools, improves standards

Structured Industry Engagement



Payment & UI Task Force - Discontinued Sept 30, 2024

Ensuring Managed Charging is Reliable

VGI projects:

- Communications TF
  - Ensure reliable AC communication while charging via pilot wake
- Outside of ChargeX Task Forces

VGI 1. Map V1G state machine and **sequence diagrams** for L2 managed charging

VGI 2. **Define performance metrics** for public L2 managed charging

VGI 3. **Analyze the reliability** of managed and scheduled charging use cases

VGI 4. **Benchmark pilot wake** capabilities of current U.S. EV makes/models

EV Charging Sequence Diagrams

Goal: Develop state-machine and sequence diagrams for EV, EVSE, and OCPP for managed charging scenarios

Progress:

- **SAE J1772 PWM Charging (Control Pilot)**
  Focuses solely on the low-level, analog control pilot and proximity handshake between EVSE and EV to establish a charge session, modulate current and end a session.

- **SAE J1772 PWM Controlled Charging with OCPP 1.6J**
  Builds on the pure PWM sequence diagram by weaving in OCPP 1.6J messages between EVSE and CSMS for session management and grid-side coordination.

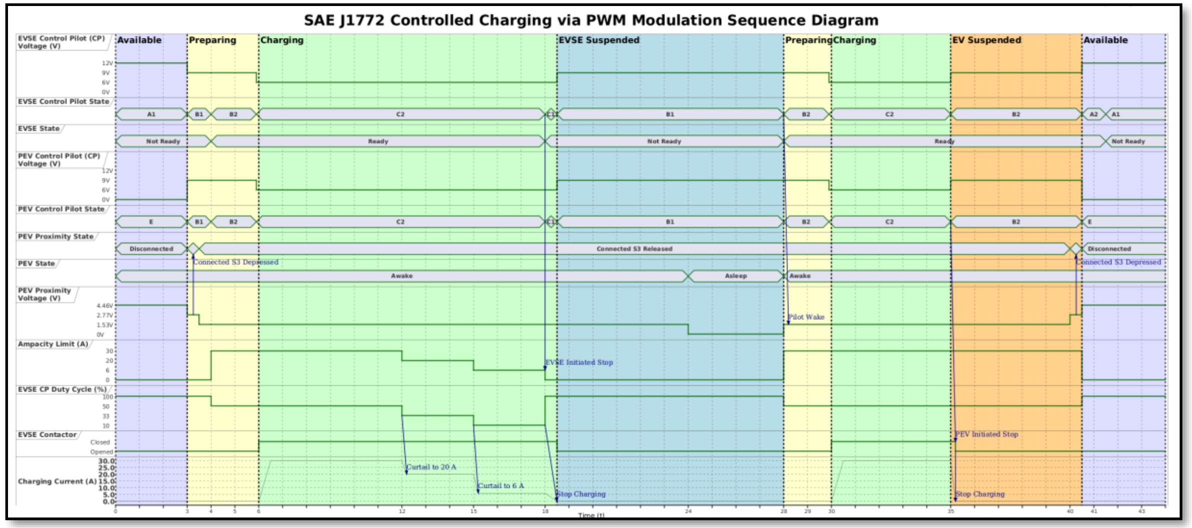
- **ISO 15118-2 Controlled Charging with OCPP 1.6J**
  Uses ISO 15118-2:2013 over HomePlug GreenPhy (HPGP) Powerline Communication (PLC) for EV ↔ EVSE and OCPP 1.6J for EVSE ↔ CSMS. The CSMS can push a charging profile to the EV, but there's no bidirectional negotiation to balance driver energy needs and departure times with grid constraints—vehicles simply follow the profile provided by the Secondary Actor via the CSMS.

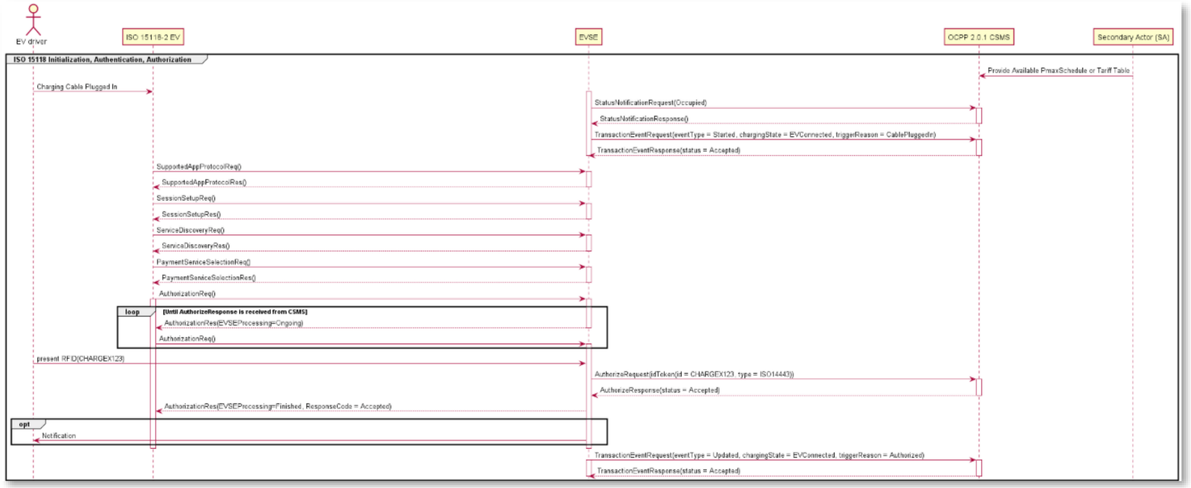
- **ISO 15118-2 HLC Optimized Charge Scheduling with OCPP 2.0.1**
  Retains the ISO 15118-2 HLC flows but upgrades to OCPP 2.0.1's richer set of messages and adds true negotiation. EV, CSMS, and optionally a Secondary Actor exchange requirements and constraints so that the final schedule optimally meets both driver departure/energy needs and grid/operator limits.

- **SAE J1772 EVSE Control Pilot FSM**
  A finite-state machine view of the SAE J1772 control pilot, ideal for understanding basic pilot-voltage state transitions.

Next Steps: Task Done

https://github.com/chargex-consortium/ev-charge-seq-state

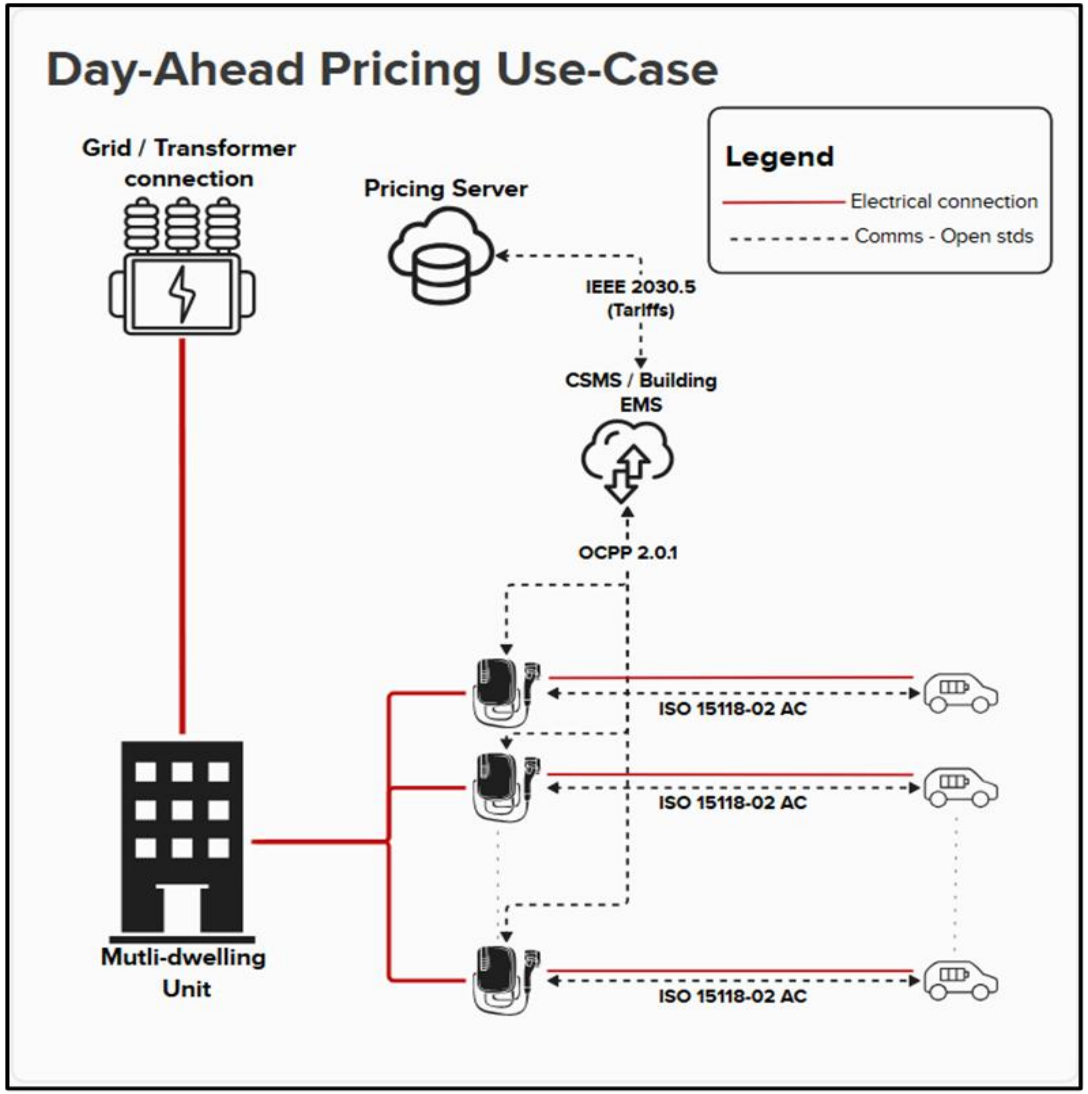




Reliability

Goal: Understand reliability issues for two smart-charging use cases by performing process failure mode and effect analysis (**PFMEA**) and suggest mitigating strategies (recommended actions) in a report.

#	Name	Description	Protocols
1	Scheduled charging via telematics	Smart charging controlled by a telematics based SCM system	SAE J1772 (PWM) EV Telematics EV OEM APIs
2	Day-Ahead Pricing	Charging is scheduled to minimize costs per LMP (Locational Marginal Pricing)	ISO 15118-02 AC OCPP 2.0.1 IEEE 2030.5 (Tariffs)



Considerations:
- User errors are not considered for PFMEA
- Payment failures are not considered for PFMEA

Potential future work:
- Two additional use-cases focused on transformer overload mitigation.
- Working on a probabilistic framework to quantify reliability as a Probability of Failure on Demand (PFD). This is designed to be modular and incorporate real-time diagnostics and metrics.

Performance Metrics

Goal:

Establish key performance indicators (KPIs) for AC Level 2 SCM that measure its performance and effectiveness from the perspective of different stakeholders for the SCM use cases/objective functions in VGI Tasks 1 and 3

Next Steps:

Publish report by June 2025 that defines the performance metrics and provides insights into data requirements for calculating the metrics

Category	KPI Name
SCM Session Success	
	EVSE communication reliability
	Event response reliability
	Energy delivery reliability
	SCM Session Start Success
	SCM Session End Success
Response time	
	Latency in Data Exchange
	Full activation time
	Response Time
	Ramp Time
	Fault/Timeout Error report latency
	Closed-loop time constant for load control
Participation and Customer Response	
	Opt-out rates
	Percent of time plugged but unavailable
	Charge time flexibility
	Charge energy flexibility
	Charge cost flexibility
	Charge elasticity
	Reduction in peak load contributions from participating EVs
	Number of managed charging events per year
	Fraction of charging events that are managed
	Managed charging participation rate
	Retention rate
Energy Metrics	
	User awareness of management
	Efficiency of charge
	Accuracy of EVSE integral meters relative to revenue-grade meter accuracy
	Accuracy of EVSE response to direct control signal
Interoperability	
	Data Exchange Failure Likelihood
	Schema Compliance Rate
	Parsing Error Rate
	Authentication/Authorization Success Rate
	Data Mapping Accuracy
	Ontology Alignment Score
	Data Consistency Rate
	System Downtime Due to Integration Issues
	Error Resolution Time

Availability
Durability
Integrity

EV Benchmarking

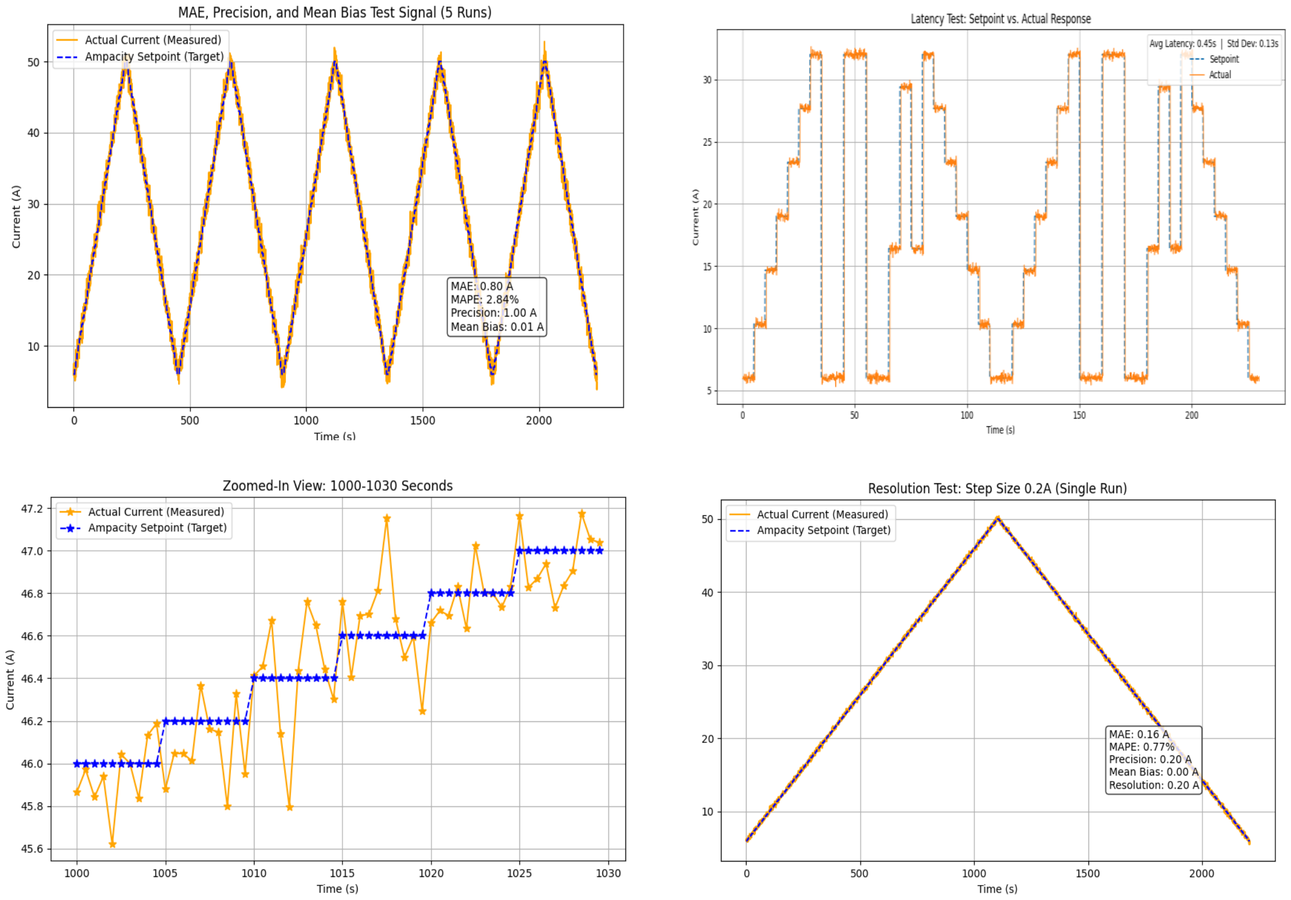
Goal: Benchmark large fraction of US available EV makes to understand charge control capabilities via SAE J1772 PWM modulation as well as pilot wake transitions.

Progress:

- Test Plans Completed
- Automation Test Scripts Developed
    - Charge control accuracy and precision, latency, and resolution
    - PWM-based charge control response: PJM RegD response score
    - EV Pilot Wake response – timeout tests

Next Steps:

- Begin Testing
- Analyze Results
- Deliver Internal Results and Industry Summary



Example results of charge control accuracy, precision, latency, and resolution tests

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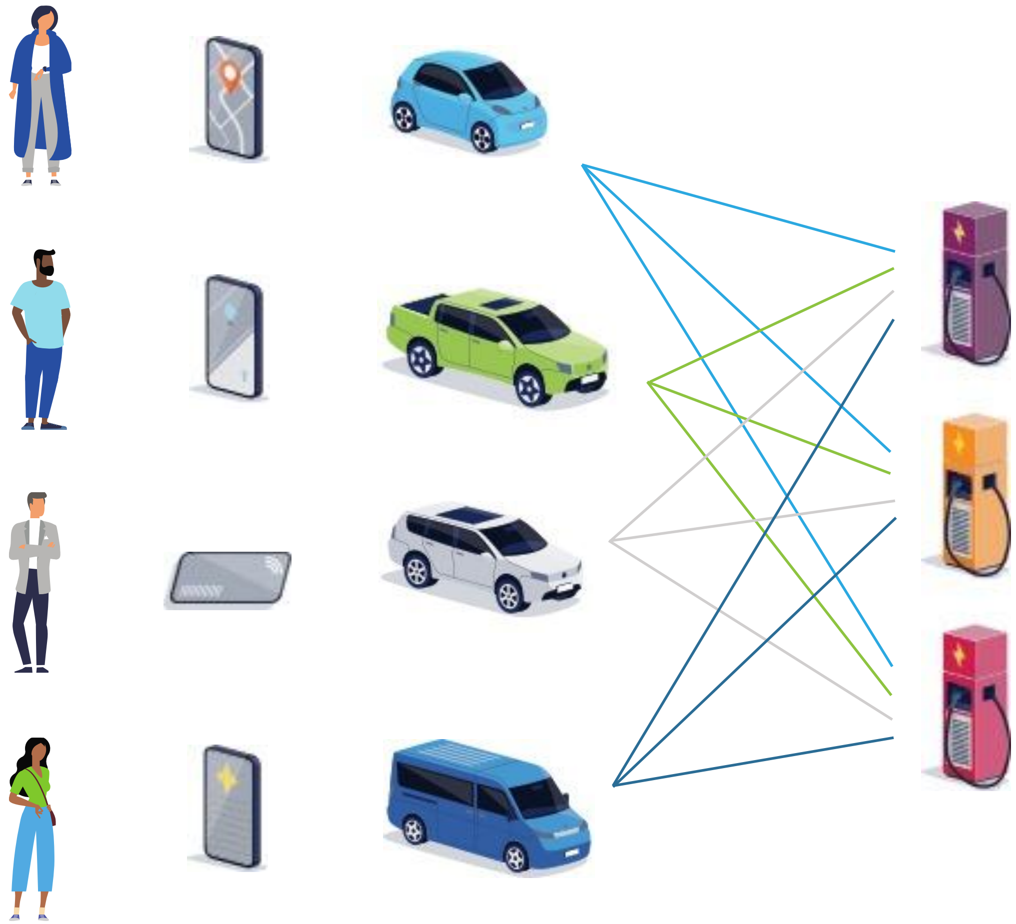

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