VEHICLE ELECTRIFICATION AND INFRASTRUCTURE, CYBERSECURITY & EMI/EMC AWARENESS – PART 2

An HTUF Webinar

June 23, 2022

Steven Sokolsky, HTUF Program Manager

Mike Dudzik, President, IQM Research Institute

CALSTART

HTUF
HIGH-EFFICIENCY TRUCK USERS FORUM

U.S. ARMY

DEVCOM

THE HTUF PROGRAM

- 3 prime focus areas:
  - Vehicle electrification (commercial > military)
  - Energy storage/export power
  - Vehicle cybersecurity
- Program funded to Summer 2022 – currently working on future funding
- Currently Supporting U.S. Army's Ground Vehicle Systems Center

Main contacts:

- **Vehicle Electrification & Cybersecurity:**
  Steven Sokolsky
  ssokolsky@calstart.org
- **Energy Storage/Export Power**
  Maureen Marshall
  mmarshall@calstart.org

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WHAT'S NEXT?

- Building industry participation in Export Power Energy Storage& and Cybersecurity working groups
  - Vehicle-based range extender
  - V2G Solutions
  - High-temp power density electronics
  - 2-3X increase in energy storage
  - High-capacity vehicle charging
- Analyzing the potential for military demonstrations of high-efficiency technologies and supporting planning efforts:
  - Energy storage technologies
  - Advanced transmissions

The goal of HTUF remains the establishment of a process to enable collaboration between the commercial vehicle industry and the military to quicken the adoption of advanced high-efficiency and zero-emission technologies

https://calstart.org/htuf/

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TODAY'S WEBINAR

Mike Dudzik, IQM Research Institute, Moderator

Professor Gene Saltzberg, University of Detroit, Mercy – The electric architecture for charging trucks

Mark Zachos, DG Technologies – EV Charging Security

Mark Steffka, Professor, University of Detroit, Mercy – EMC Considerations in Truck Fleet Charging Installations

Q&A

HIGH-EFFICIENCY TRUCK USERS FORUM

Q & A

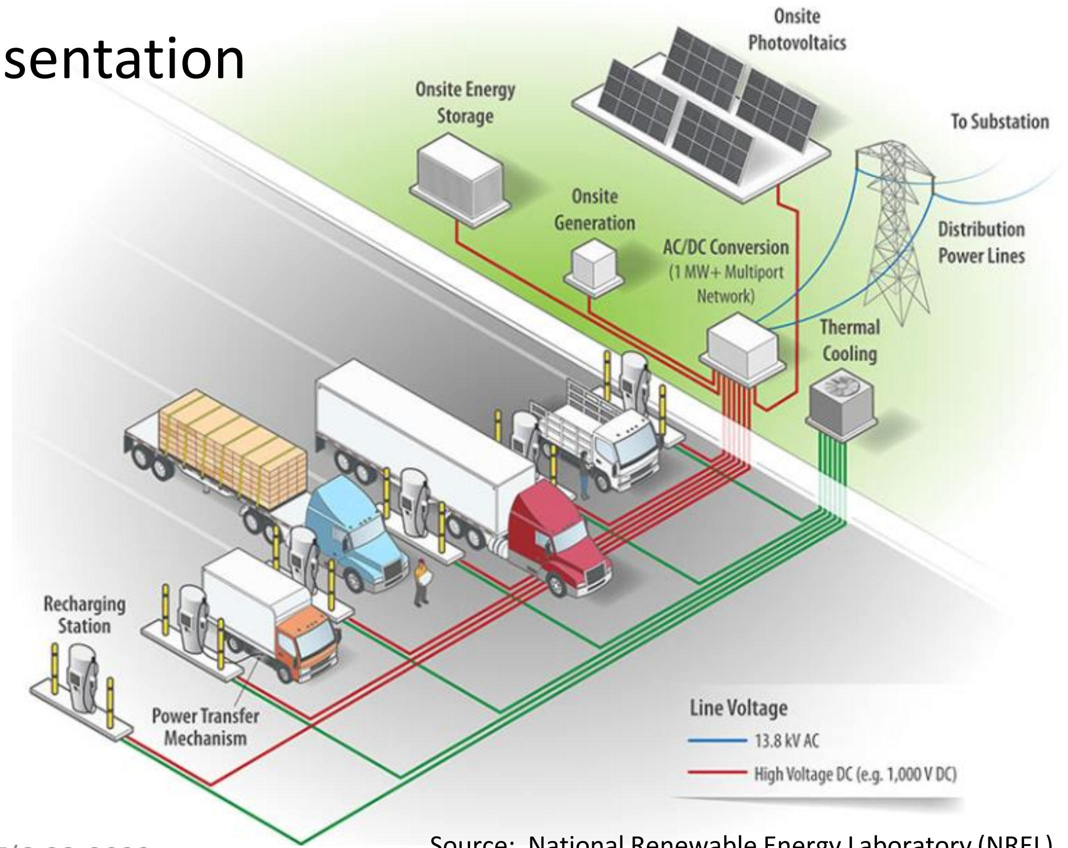
Submit your questions using the tab below

Truck Charging Architecture

Gene Saltzberg
Adjunct Professor University of Detroit Mercy
Teaching - Energy Storage Systems, Charging, Fuel Cells
Retired GM, EV Charging Systems Engineer

Overview of Presentation

- EV Charging Standards Review
  - Power Levels
  - Connectors
  - Charging times
  - Wireless Charging
- Truck Charging
  - UL Standards Development
  - Charging Station Architecture
  - Wireless Charging



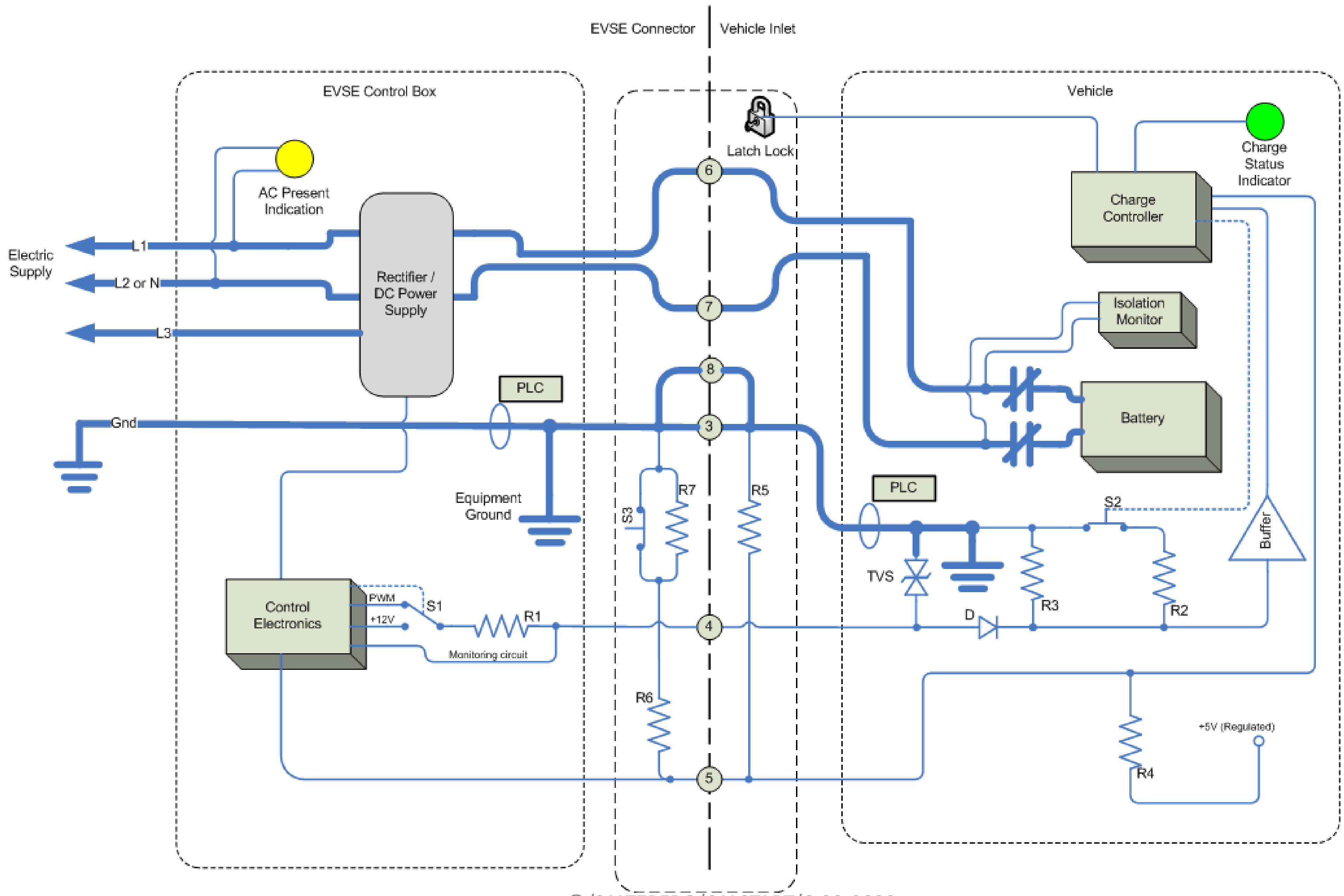
Source: National Renewable Energy Laboratory (NREL)

SAE J1772 standard

- North America Standard
  - Standard for AC Level 1 and AC Level 2 charging and DC Level 3 charging
  - Combined Charging System (CSS)1 Connector Type Used in North America
  - CSS2 Connector Type Used in the EU
  - Communication / Signal Definition
  - Compatibility between vehicles and charging stations
  - Safety
- Country and region specific charging standards.
- Commonization is needed.

	CHAdeMO	GB/T	US-COMBO CCS1	EUR-COMBO CCS2	Tesla
Connector					
Inlet					
IEC	✓	✓	✓	✓	
	IEEE		SAE		
EN	✓			✓	
JIS	✓	✓	✓	✓	
GB		✓			
Protocol	CAN		PLC		CAN
Max Power	400kW 1000x400	185kW 750x250	200kW 600x400	350kW 900x400	?
Market Power	150kW	125kW	150kW	350kW	120kW
Connectors #	27,500	300,000	3,000	11,000	20,000
Start @	2009	2013	2014	2013	2012

Charging Power Levels Based in Part on SAE Standard J1772					
Power Level Types	**Charger Location**	**Typical Use**	**Energy Supply Interface**	**Expected Power Level**	**Charging Time**
Level 1 120 Vac (US) 230 Vac (EU)	On-board	Charging at home or office	Convenience outlet (NEMA 5- 15R/20R)	1.4kW (12A) 1.9kW (20A)	4-100 hours
Level 2 240 Vac (US) 400 Vac (EU)	On-board	Charging at private or public outlets	Dedicated EVSE	8kW (32A) 19.2 kW (80A)	1-20 hours 0.5-10 hours
Level 3 (Fast) (208-1000 Vdc)	Off-Board	Commercial, analogous to a filling station	Dedicated EVSE	50kW **400kW**	0.2-4 hour **5-30 minutes**


EVSE Connector
Vehicle Inlet
EVSE Control Box
Vehicle
Latch Lock
Charge Status Indicator
Charge Controller
AC Present Indication
Electric Supply
L1
L2 or N
L3
Rectifier / DC Power Supply
Isolation Monitor
Battery
PLC
Gnd
Equipment Ground
S3
R7
R5
PLC
S2
TVS
R3
R2
Buffer
D
Control Electronics
PWM
+12V
S1
R1
Monitoring circuit
R6
R4
+5V (Regulated)
6
7
8
3
4
5

UL Charging Standard

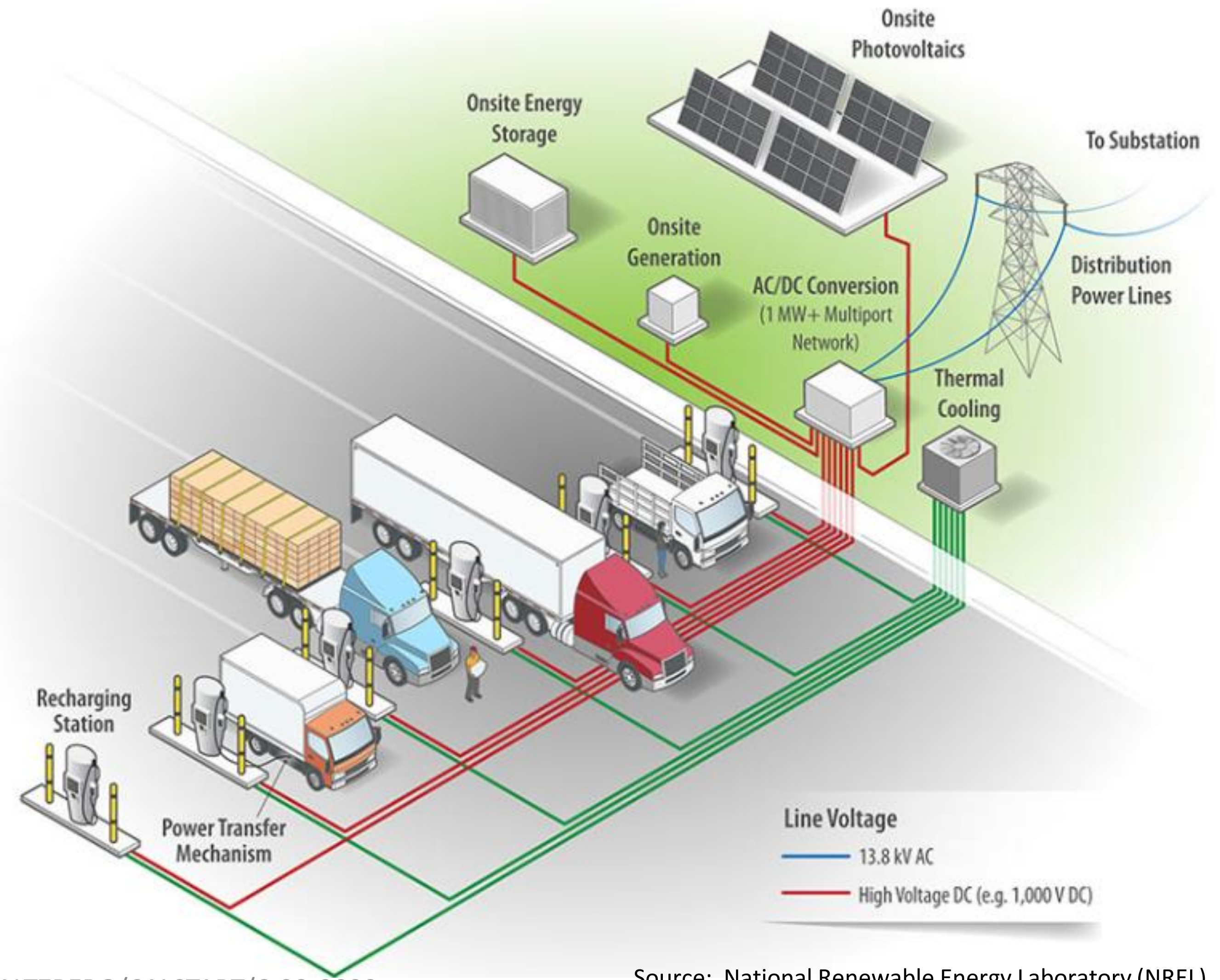
- Electric Vehicle (EV) Standards
  - UL 2202, the Standard for EV Charging System Equipment up to 600 V
  - UL 2594, the Standard for EV Supply Equipment
  - UL 2251, the Standard for Plugs, Receptacles, and Couplers for EVs
  - UL 9741, Bidirectional EV Charging System Equipment
- Truck and Bus Charging Standard (Proposed) - 1500 Vdc, 3000 A, 4.5MW
  - Will require different charge protocols and configurations
  - This is intended for use by skilled personnel, not the general public
- Alternative to Single High Current Connections
  - Multiple EV Charging Ports via EV Standards
  - Split Battery Pack into multiple sections
- Grid
  - Need to mitigate the grid peak power usage
  - Stations would need to have the ability to store energy

Range Chart

Model	Range (mi)	Battery (kWh)	Charge time(hrs)			(min)	(min)
			2 kW	10 kW	20 kW	400 kW	4.5MW
Class 8 Truck (2)	**?**	**600.0**	**300.0**	**60.0**	**30.0**	**90.0**	**8.0**
Class 8 Truck (1)	**?**	**300.0**	**150.0**	**30.0**	**15.0**	**45.0**	**4.0**
GM GMC Hummer SUV	350	200.0	100.0	20.0	10.0	30.0	
Rivian R1S (400)	400	180.0	90.0	18.0	9.0	27.0	
Rivian R1T (400)	400	180.0	90.0	18.0	9.0	27.0	
GM BrightDrop EV600	250	172.0	86.0	17.2	8.6	25.8	
GM GMC Hummer SUT	300	172.0	86.0	17.2	8.6	25.8	
Ford F150 Lightning (Extended)	300	170.0	85.0	17.0	8.5	25.5	
GM BrightDrop EV410	250	147.0	73.5	14.7	7.4	22.1	

Electric Truck Charging Station Architecture

- Power Transfer Component
  - Power Conversion
- Network Charging Controller
- Energy Source
  - Grid
    - Oil
    - Gas
    - Coal
    - Nuclear
    - Solar
    - Wind
    - Hydropower
  - Solar
  - Generator (Backup)
  - Energy Storage System
    - Batteries
    - Hydrogen



Source: National Renewable Energy Laboratory (NREL)

Source: Engineering Society Presentation while at GM 4/2010 - E. Saltzberg/K. Newton

Tank System Weight and Volume

Range: 500 km

	Diesel	Compressed Hydrogen 700 bar	Lithium Ion Battery
		6 kg H_2 = 200 kWh chemical energy	100 kWh electrical energy
Weight – System	43 kg	125 kg	830 kg
Weight – Fuel / Cell	33 kg (Fuel)	6 kg (Fuel)	540 kg (Cell)
Volume – System	46 L	260 L	670 L
Volume – Fuel / Cell	37 L (Fuel)	170 L (Fuel)	360 L (Cell)

Truck Charging Management Scenarios

- Scenario 1
  - 24 trucks
    - 1 Needs to be charged every hour per day
    - Each truck battery capacity 500 kWh
  - Total power consumed per day 12 MWh
  - 12 hours of light per day on average
    - Requires 1 MW solar panels
    - ~5000 solar panels (Panel ~ 5’X2’) 50,000 square feet (~1 Acre)
  - 12 hours of dark per day on average
    - Requires 6 MWh energy storage

- Scenario 2
  - 24 trucks
    - 1 Needs to be charged every hour per day
    - Each truck battery capacity 500 kWh
  - 6 hours of Peak Utility charges
  - Total power consumed during peak utility charges 3 MWh
  - 12 hours of light per day on average
    - Requires 250 kW solar panels
    - ~1,250 solar panels (Panel ~ 5’X2’) 12,500 square feet
  - For the 6 hours of peak utility
    - Requires 1 - 3 MWh energy storage

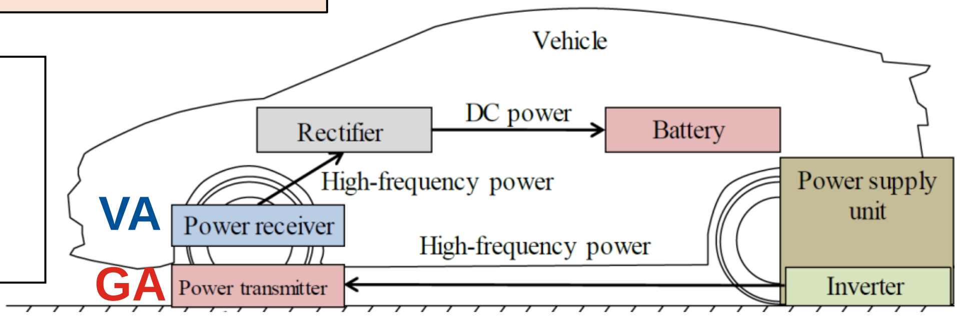
Wireless Power Transfer (WPT)

- Light Duty WPT Specification - SAE J2954 Standard
  - Power Transfer in 4 power levels WPT 1-4 (3.7kW, 7.7kW, 11kW up to 22kW)
  - Air Gaps from 100-250mm (up to 10 inches)
  - Minimum Efficiency 80-85% misaligned/aligned
  - Suppliers are reporting efficiencies at 93%
  - Operating Frequency: 85kHz
- Truck Wireless Charging 1000kW (J2954/2)
  - DOE Project to Develop Class 8 Wireless Charging System
  - Kenworth and Wireless Advanced Vehicle Electrification (WAVE), a developer of high-power inductive charging solutions for medium- and heavy-duty vehicles
  - Each charging station will deliver 1-megawatt of power from roadway-embedded charging pads
  - 1-megawatt Wireless Charger aims to charge batteries in ~30 minutes
  - Fully-automated charging simplifies the electrification process

Standardization
Interoperability with GAs and VAs from different manufacturers

High-voltage safety and reliability
Failsafe function, insulation, detection of current leakage,

EMC, EMF, ICNIRP
Reducing emission, protection from the effects of electromagnetic fields(EMF).

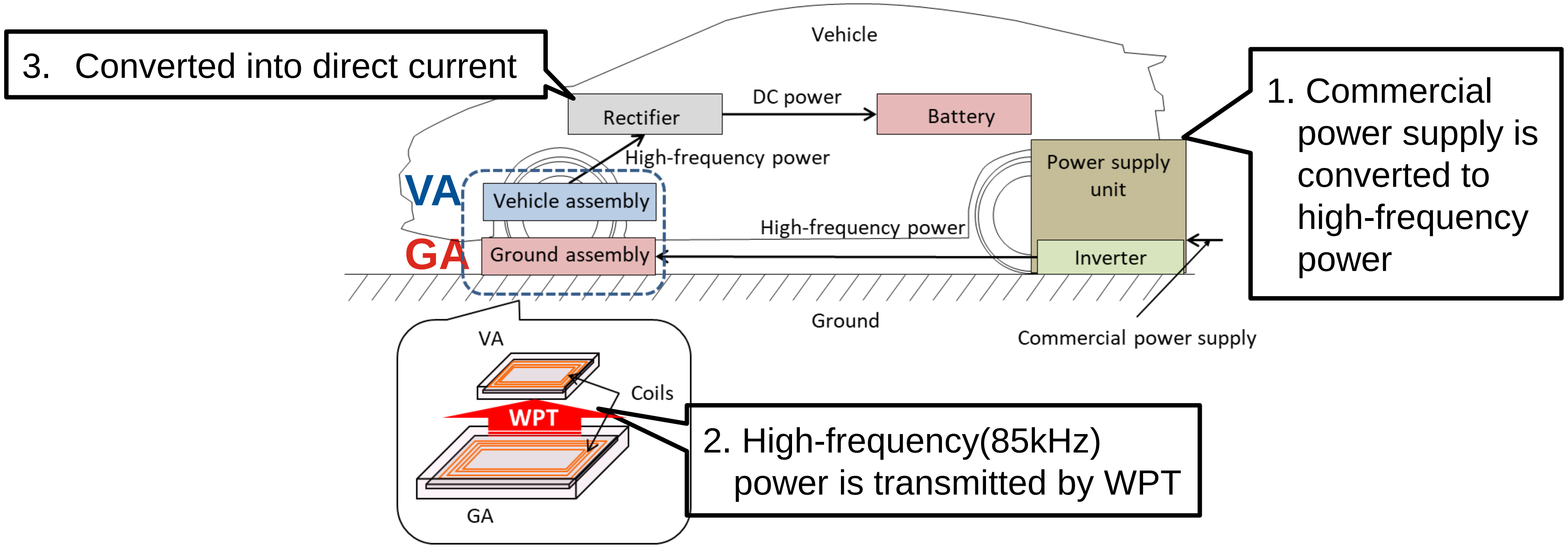


Foreign and living object detection
To provide protection from electromagnetic fields

Parking support system
It detects, restricts, and notifies the user of misalignment between two coils.

Wireless Power Transfer (WPT)

System includes a power transmitter mounted on the ground (GA), and a power receiver mounted on the vehicle (VA).



https://www.youtube.com/watch?v=GlrcPrzuPMM
https://www.youtube.com/watch?v=6qoHCMy-laA

Q&A

Thank you

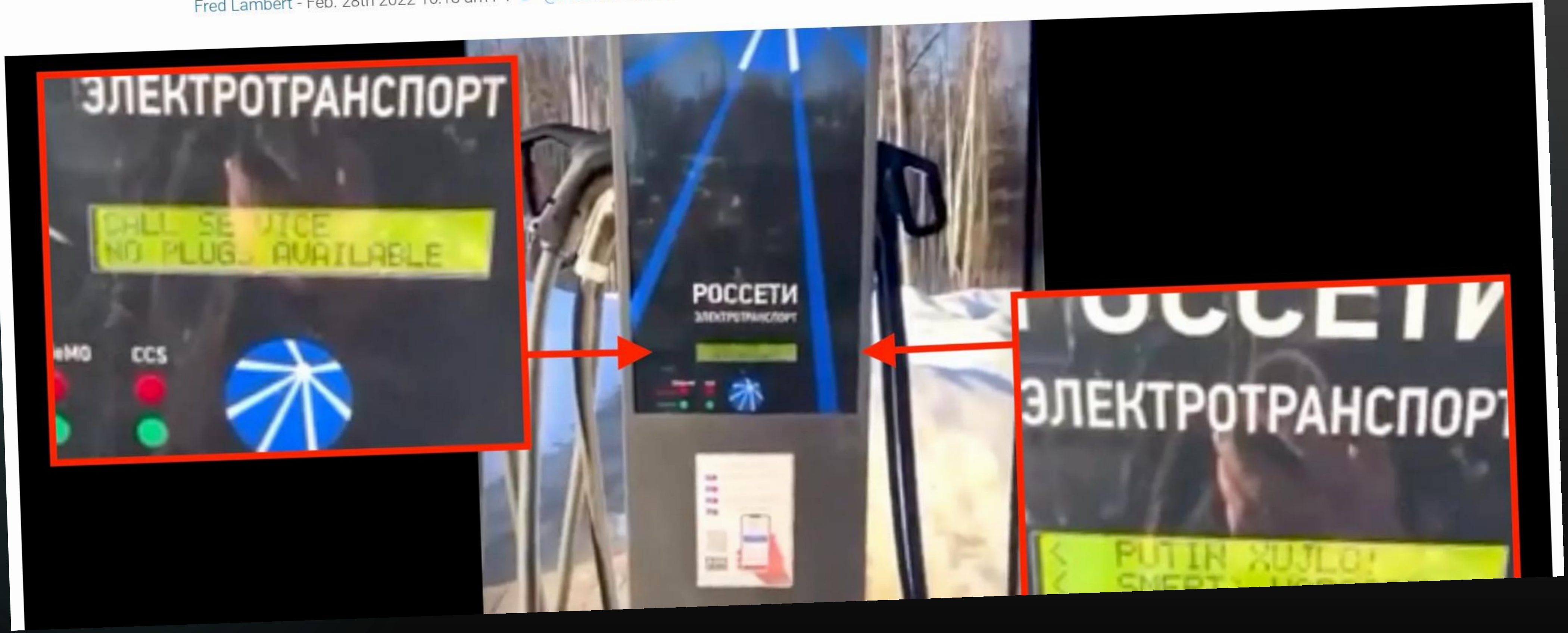
CALSTART
EV Charging
Secuirty

JUNE 23, 2022

MARK ZACHOS

Hacked electric car charging stations in Russia display ‘Putin is a d*ckhead’ and ‘glory to Ukraine’

Fred Lambert - Feb. 28th 2022 10:13 am PT @FredericLambert



Recommended

Cybersecurity Practices

for

EV Charging Systems

CYBERSECURITY CONSIDERATIONS

- There is a dramatic increase in the quantity of electric vehicles (EVs) and EV supply equipment (EVSE). High power EV chargers are commonly being installed at workplaces and publicly-accessible locations.
- EVSE cybersecurity attacks may impact many critical infrastructure sectors (e.g., transportation systems, energy, emergency services, manufacturing).
- Combined use of smart-grid technologies, mobile applications,and back-end networking systems introduces several risks, including:
  - New attack vectors for the U.S. electric grid
  - Loss of customer data such as personally identifiable information and financial information
  - Control of the EVSE cyber-physical system through the Internet, potentially offering a foothold on internal enterprise networks

CYBERSECURITY IMPACTS

- EVSE providers, grid operators, vehicle manufacturers, and government agencies must understand cyber-attacks targeting EVSE chargers can create both localized and widespread impacts:

Local impacts
- Theft of PII and financial information
- Failure to charge vehicle
- Damage to batteries or other EV components
- Compromise of EVSE life-safety systems
- Loss of EVSE service availability

Large-scale impacts
- Harvesting of PII and financial information
- Shutdown of entire EVSE charging network
- Exposure of upstream and partner IT networks
- Misconfiguration of EVSE creating damaging or dangerous conditions
- Loss of consumer confidence in EVSE ecosystem
- Bulk power system impacts

PREVALENT WEAKNESSES IN ELECTRIC VEHICLE SUPPLY EQUIPMENT

Physical Access
- Failure to log or generate an alarm when internal compartments are accessed.
- Unencrypted storage allows attackers to steal credentials for use in accessing EVSE or partner systems, networks, and cloud services.
- Spacious internal compartments allow placement of malicious hardware to obtain PII or financial information.
- Attackers can modify or damage internal power electronics and safety systems.
- Insufficient physical measures to deter and identify intrusions.

System Hardening
- Unused, enabled network ports in use.
- Debugging ports are not removed prior to deployment.
- Default or system accounts, using common credentials, prevent accountability for malicious activities.
- The use of common credentials prevents system administrators from revoking access when personnel leave the organization or no longer require access.

Network Protection & Monitoring
- EVSE networks do not always support encryption across necessary data modalities, such as at rest or in transit.
- Intrusion Detection Systems (IDSs) are not installed at key network locations, e.g., IT/OT DMZs and cloud firewalls.
- Lack of proper network segmentation in enterprise systems and EVSE networks.
- Regular vulnerability scanning and patching of backend/cloud infrastructure is not performed by EVSE owners/operators.

Best Practices

BUSINESS NETWORK & OPERATIONS

- ☑ Implement secure coding practices including integrity checks of code repositories and version controlling.
- ☑ Use separation of privilege for all EVSE-related operations.
- ☑ Ensure cybersecurity best practices like the NIST Cybersecurity Framework are used for internal assessments, cyber hygiene, patching, supply chain and insider threat mitigations, etc.

EVSE SECURITY

- ☑ Implement tamper-detection sensors and alarms on EVSE enclosures.
- ☑ Prioritize alarms and ensure timely actions on critical log events.
- ☑ Encrypt all information storage devices within the EVSE.

EVSE NETWORK

- ☑ Use network segmentation and VLANs to isolate EVSE installations.
- ☑ Install firewalls and IDSs at key network locations.
- ☑ Encrypt all network traffic using a FIPS 140-2 compliant cryptographic module.
- ☑ Disable unnecessary services and ports.
- ☑ Ensure proper defense in depth by limiting external access to device to only authorized users and devices using access control technologies.

EVSE OPERATIONS

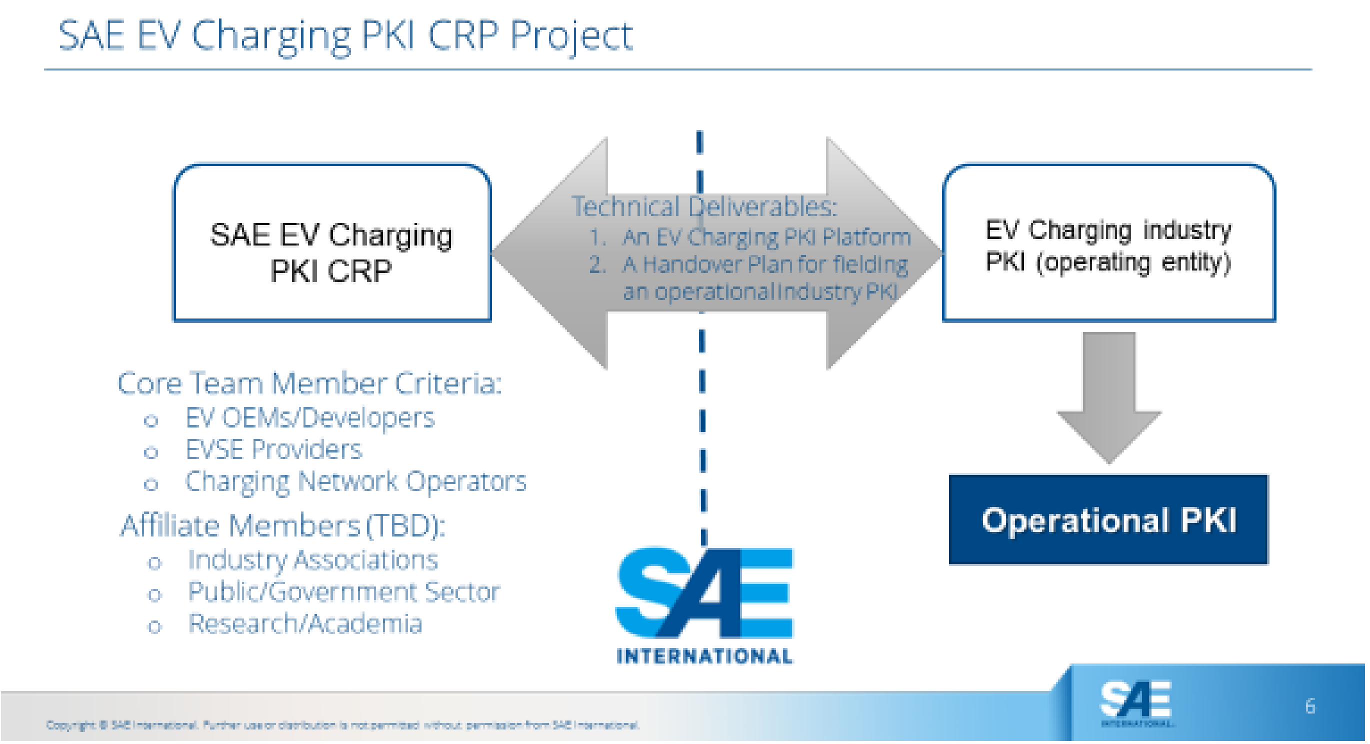
- ☑ Validate all network traffic and EV inputs before routing them into the EVSE OT network.

Sandia National Laboratories

SAE Update - Ground Vehicle Standards

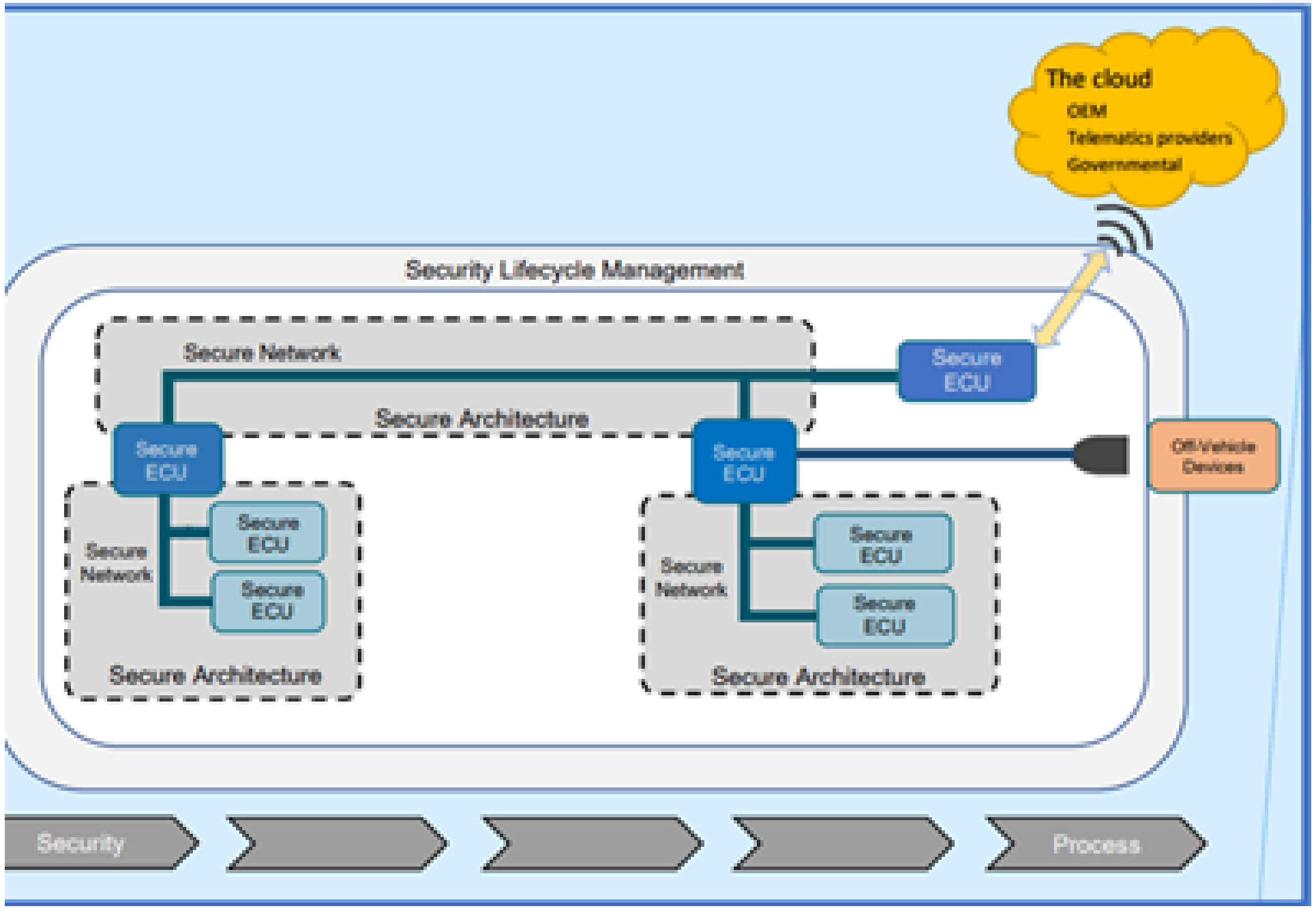
Developing a Secure EV Charging Ecosystem

SAE Cooperative Research Project (CRP)



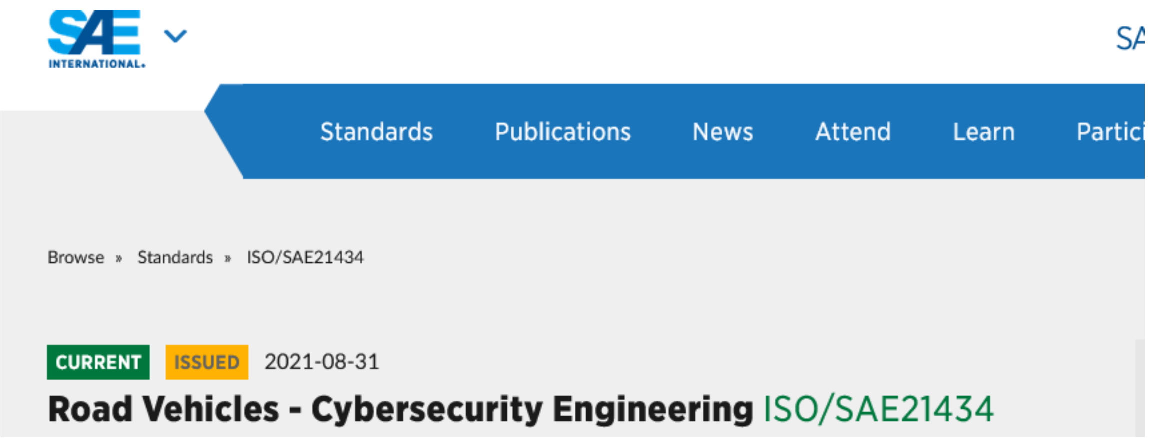
SAE J1939 Network Security

- **SAE J1939-91A Vehicle Network Secure Architecture** (in ballot)
- SAE J1939-91B Wireless Interface Security (starting draft)
- **SAE J1939-91C Secure ECU-to-ECU Communications** (CRP)



ISO/SAE 21434

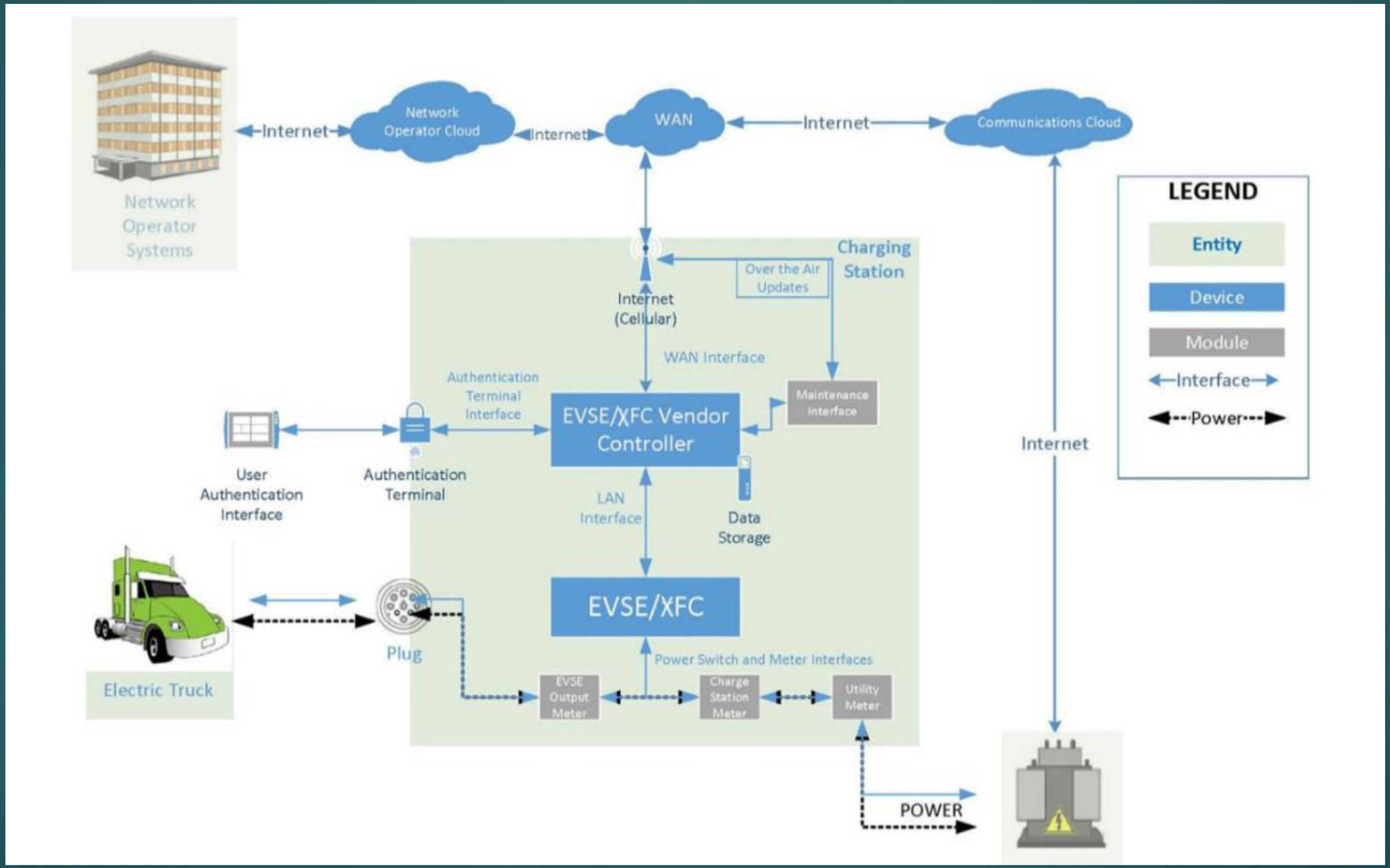
- Engineering requirements for cybersecurity risk management regarding concept, product development, production, operation, maintenance and decommissioning of electrical and electronic (E/E) systems in road vehicles, including their components and interfaces.



ISO 15118-20

- Transport Layer Security (TLS) 1.2 and above is used to encrypt the communication channel on the transport layer. On the application layer, XML-based digital signatures and X.509v3 certificates are used to verify the authenticity of the sender and the integrity of some of the exchanged messages.

Extreme Fast Charging (XFC)
Cybersecurity Threats, Use Cases and Requirements
For Medium and Heavy Duty Electric Vehicles



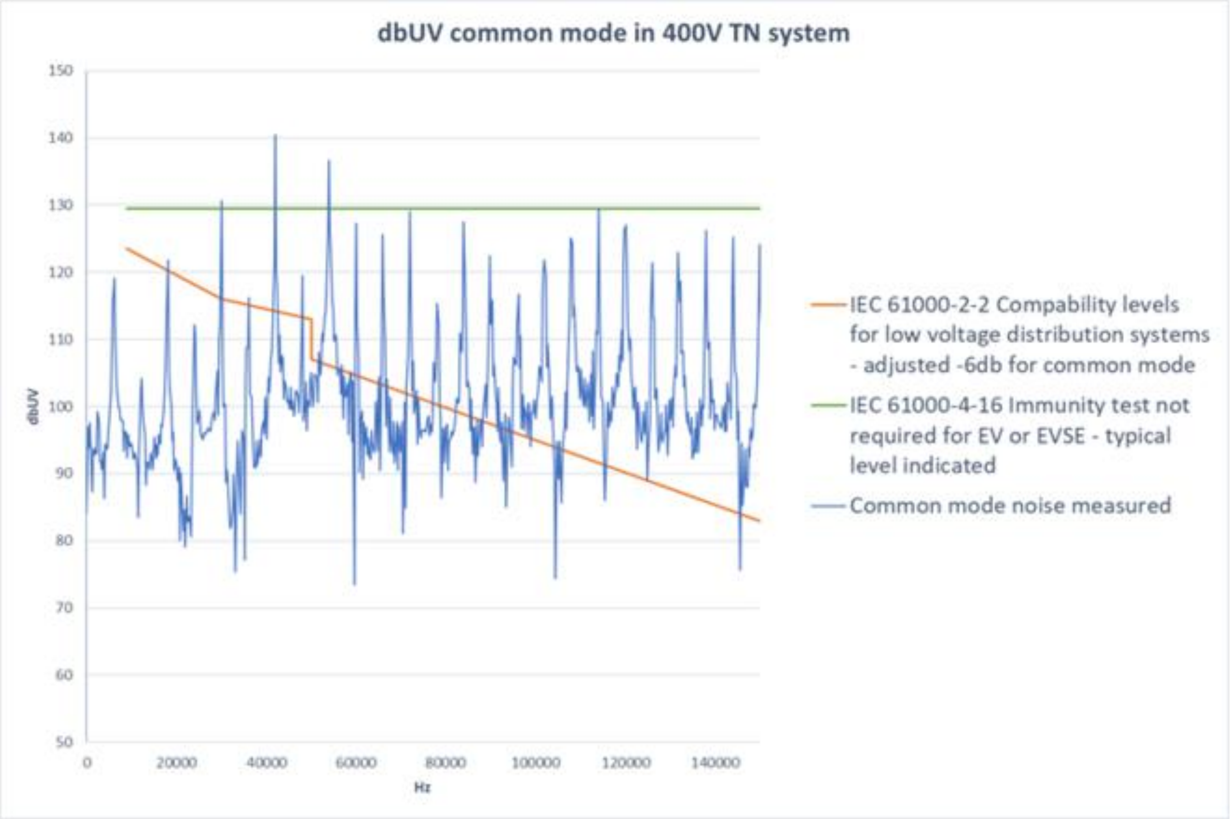
EMC Considerations in Truck Fleet Charging Installations

- Truck fleet charging facilities will contain many charging stations at various power levels and (possibly) a mix of charging methods (conductive and “wireless”).
- Facilities must be designed to minimize the unintended coupling of energy during the charging process (and “harden” the intended transfer of energy that could provide a path to introduce cybersecurity risks).
    - Conductive charging systems may need to be to be alternated with wireless systems to provide physical separation.
    - For conductive charging systems the cables’ lengths and geometric orientation to each other need to be carefully considered (to minimize coupling).
- Other support equipment used for the charging facility infrastructure may affect the correct operation of charging systems.

Example of Potential Charging Facility Effects Upon Charging Systems' Operation

- **Unitech Power Systems AS has recently identified electromagnetic noise sources that prevented electric vehicles charging in a parking garage.**
- Unitech Power Systems AS has recently provided assistance with investigating the cause of electric vehicle chargers malfunctioning in P-Siddis – a parking garage in Stavanger, Norway. Measurements showed high levels of conducted noise – so called "common mode" voltages – that caused the chargers' control of its contactors to malfunction

During the troubleshooting the source of noise was identified to be variable speed drives for the parking garage's exhaust fans. Mitigation measures have been proposed.



Potential Electromagnetic Interference Types from Charging Facilities

- Coupling of primary power 60 Hertz electric and magnetic fields due to leakages from input transformers and/or long power input cabling.
- Switching frequencies used in the charging electronics (and harmonics of the those frequencies). *Lower frequencies are most commonly transferred by cabling (known as "Conducted Emissions") and the harmonics are more efficiently transferred as "Radiated Emissions".*
- Intended radio frequency (RF) fields used to communicate with the vehicles being charged, or the power distribution system supplying the charging energy.

Applicable United States' EMC Regulations and Standards

- Charging stations installations equipped with power electronics (for charging energy transfer) and devices to communicate with "the cloud" are required to be tested to FCC "Part 15".

FCC Part 15	
Class A	Class B
Controlled commercial and industrial locations	Residential environments for safety in general public
Less stringent requirement Where controlled locations have the resources to correct potential safety concerns.	**More stringent requirement** Devices are measured in closer proximity to ensure safety for the general public.

If a charging station does not have Class B certification, it must display a warning label to caution users that magnetic fields around it can be problematic. In some cases, it can be high enough to affect individuals with pacemakers or other critical medical devices. Ensure your electric vehicle charging station meets the highest EMC compliance for optimal safety, lowest user risk, and equipment longevity.

Additional Considerations in the Deployment of Charging Stations

- Charging facilities should be for evaluated the electromagnetic fields (EMF) levels generated to insure those are below levels that may affect implanted medical devices such as pacemakers.
- Localized “hot spots” of EMF’s may exist in charging facilities and the ability for people to be in those ability physical locations should be restricted from public (“uncontrolled”) access.
- Installations near airports may need to undergo more stringent EMI evaluation and testing due to the potential to cause disruption to critical aircraft communication and navigation systems.

Electromagnetic Fields and Safe (Environmental) Exposure Levels

- Charging installations should be evaluated for their generation of electric and magnetic field intensity with regards to maximum exposure levels that have been determined to be safe to the general public.
- Recent study by California High Speed Rail Project can be used as guidance as to assessment process and reference documents.

CALIFORNIA
High-Speed Rail Authority

California High-Speed Rail Project

San Francisco to San Jose Project Section

FINAL
ENVIRONMENTAL IMPACT REPORT/
ENVIRONMENTAL IMPACT STATEMENT

VOLUME 1: REPORT

Prepared under CEQA and NEPA by:

California High-Speed Rail Authority
770 L Street, Suite 620 MS-1
Sacramento, CA 95814
Contact: Serge Stanich
916-324-1541

NEPA Cooperating Agencies:

U.S. Army Corps of Engineers
San Francisco District
450 Golden Gate Avenue, 4th Floor
Room 1111
San Francisco, CA 94102
Contact: Bryan Matsumoto
415-503-6786

Surface Transportation Board
Office of Environmental Analysis
395 E Street, SW
Washington, D.C. 20423
Contact: David Navecky
202-245-0294

June 2022

People with sensory disabilities may contact the Authority by phone or via the Authority website to request accessibility support.

CEQA: This document has been prepared pursuant to the California Environmental Quality Act (CEQA). The California High-Speed Rail Authority is the state lead agency.

NEPA: This document has been prepared pursuant to the National Environmental Policy Act (NEPA). The environmental review, consultation, and other actions required by applicable federal environmental laws for this project are being or have been carried out by the State of California pursuant to 23 U.S.C. 327 and a Memorandum of Understanding (MOU) dated July 23, 2019, and executed by the Federal Railroad Administration (FRA) and the State of California. Pursuant to the MOU, the California High-Speed Rail Authority is the federal lead agency. Prior to the July 23, 2019, MOU, the FRA was the federal lead agency. Accordingly, and per the above, the Authority is both the CEQA and NEPA lead agency for this project.

Summary of Issues in Truck Fleet Charging Stations' EMC

- Truck Fleet charging stations will need be deployed as the world moves to electrification of transportation vehicles.
- Charging stations should be capable of providing charging via conductive and "wireless" methods.
- The integration of energy transfer methods for battery recharging and the communications systems used to optimize charging process will require significant evaluation of both the electrical architectures and physical layout of the systems in order to provide high performance systems that are safe, resistant to effects of EMI, with minimal generation of their own undesired electromagnetic fields.