Medium- and Heavy-Duty Zero-Emission Vehicle Standardization Assessment: BEV Charging

Consultatory Meeting #2

Professor Scott Samuelsen (PI)
Dr. Kate Forrest (PM)

June 14, 2022

Advanced Power and Energy Program
University of California, Irvine

Meeting Agenda

- **Project Goal, Objectives, and Timeline**
- Consultatory Meeting #1 Summary
- Consultatory Meeting #2
  - Meeting Goals
  - Status of the Initiative
  - Feedback
  - Discussion Questions
  - Open Q&A
- Next Steps for the Second Year

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Project Overview – Project Goal

- UCI is conducting a two-year CARB contract to assess:
  - Status of standards for
    - Charging Battery Electric MHD Vehicles
    - Fueling Hydrogen Fuel Cell Electric MHD Vehicles
- Overall Goal
  - Assure standards are evolving to proactively enable the zero-emission MHDV market
  - Identify specific government actions that may facilitate timely evolution
- Project Began 1 May 2021
- Consultatory Group Meetings
  - Two a Year
  - This is meeting #2
  - Summarize UCI findings to date, obtain input and guidance

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Project Overview - Objectives

Standards Organizations Collaboration	Collaborate with and utilize standards organizations to monitor developments, track activity, and inform the analyses conducted in other tasks.
Standards Review	Assess the status of standardization and associated activities within the context of State goals.
Consultatory Group Meetings	Convene a program consultatory group to create a public forum for key stakeholders to facilitate relationships and discussion on MH-ZEV infrastructure standardization
Online Informational Resource	Publish an informational resource online for standardization processes, for government and stakeholders to understand the role and status of standardization
White Paper	Provide a White Paper on standardization status, outlook, and priorities, as well as policy recommendations

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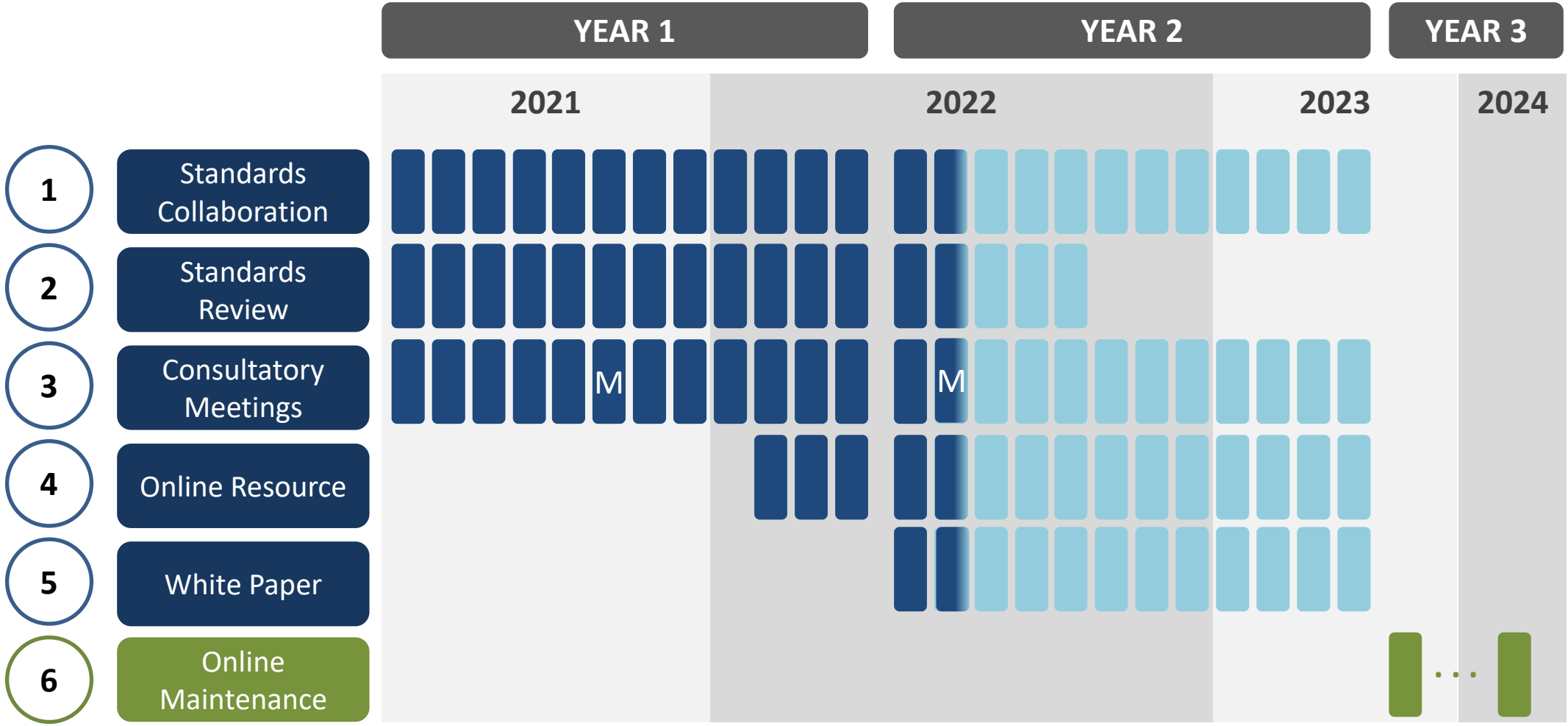
Project Overview - Timeline

2 Years + 1 Year online maintenance: 1 May 2021 to 30 April 2024



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Consultatory Meeting #1 Summary

October 19, 2021

- **Overview of Project Motivation, Goal, and Standards Scope**
- **Current MH-ZEV Market**
- **Current Infrastructure Standardization Efforts**
- **Potential Government Actions**

- **Consultatory Meeting #1 slides available online: https://www.apep.uci.edu/MHDV_Protocol_Comment.html**

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Meeting Goals

- **Present initial findings on:**
  - **The status for standardizing charging on-road MHD battery electric vehicles**
  - **Early insights into market-driven consensus**
  - **Active initiatives in the development of standards**
  - **State actions (if any) that might be useful to facilitate the process, such as staffing, grants, sponsorship, membership, etc…**

- **Solicit feedback on the UCI assessment**

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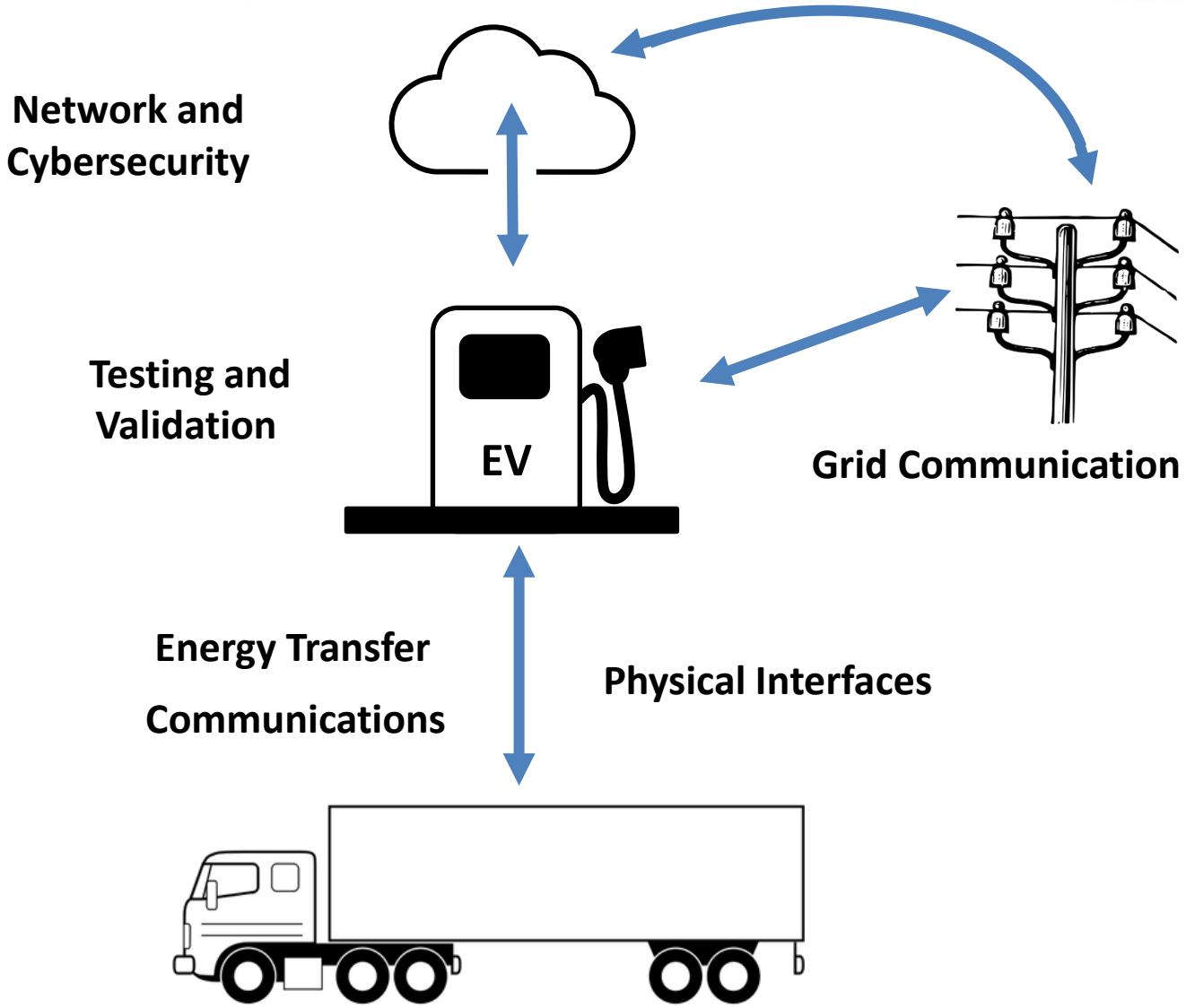
Status: Standards within Project Scope



Interim Report 1

Year 1 Topics	Year 2 Topics
Literature Review	**(Grid) Communications**
Current Market	**Testing and Validation**
Energy Transfer	**Network and**
Physical Interfaces	**Cybersecurity**
Standardization Efforts	Industry Feedback
Current Standards Gaps	Policy Actions

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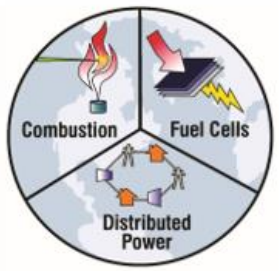
Status: Interim Report 1

Medium- and Heavy-Duty Zero-Emission Vehicle Fueling and Charging Standardization Assessment

Interim Report 1

CARB Contract 20MSC006



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www.apep.uci.edu

March 2022

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Status: Standards Organizations Within Scope

- SAE (Society of Automotive Engineers) International
- International Organization for Standardization (ISO)
- International Electrotechnical Commission (IEC)
- Institute of Electrical and Electronics Engineers (IEEE)
- American National Standards Institute (ANSI)
- ASTM (American Society for Testing and Materials) International
- National Fire Protection Association (NFPA)
- European Committee for Standardization (CEN)
- European Committee for Electrotechnical Standardization (CEN-CENELEC)
- European Telecommunications Standards Institute (ETSI)

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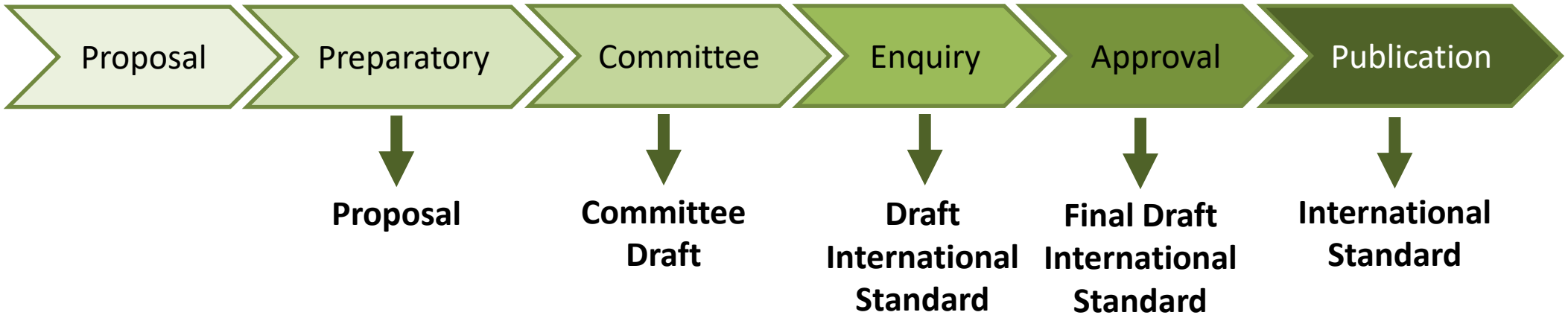
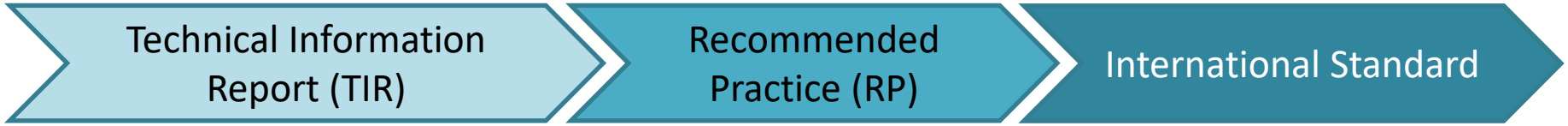
Status: Standards Document Types and Stages

ISO Stages and Documents



SAE Document Types



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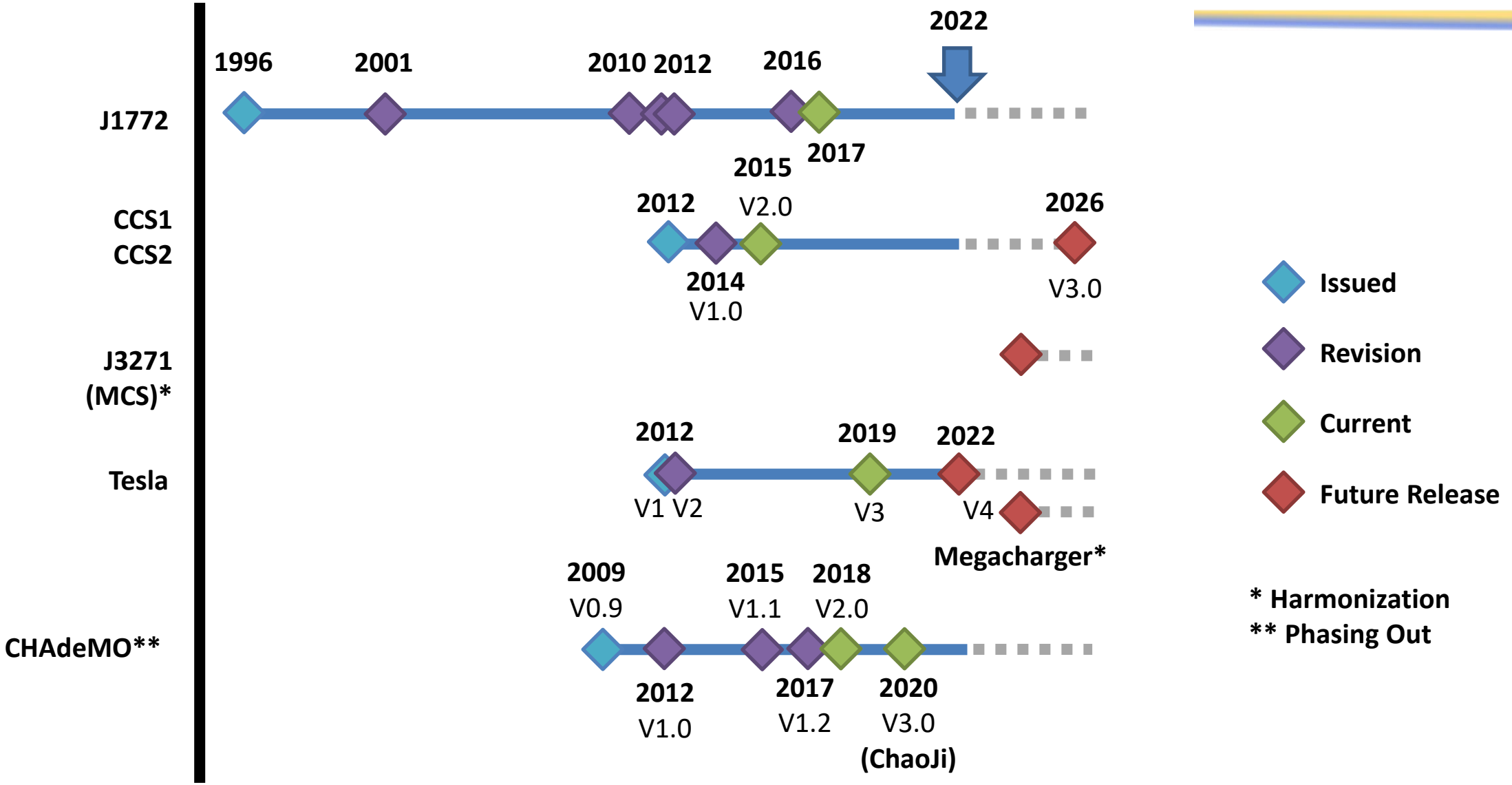
Status: Standards Timeline and Trajectories



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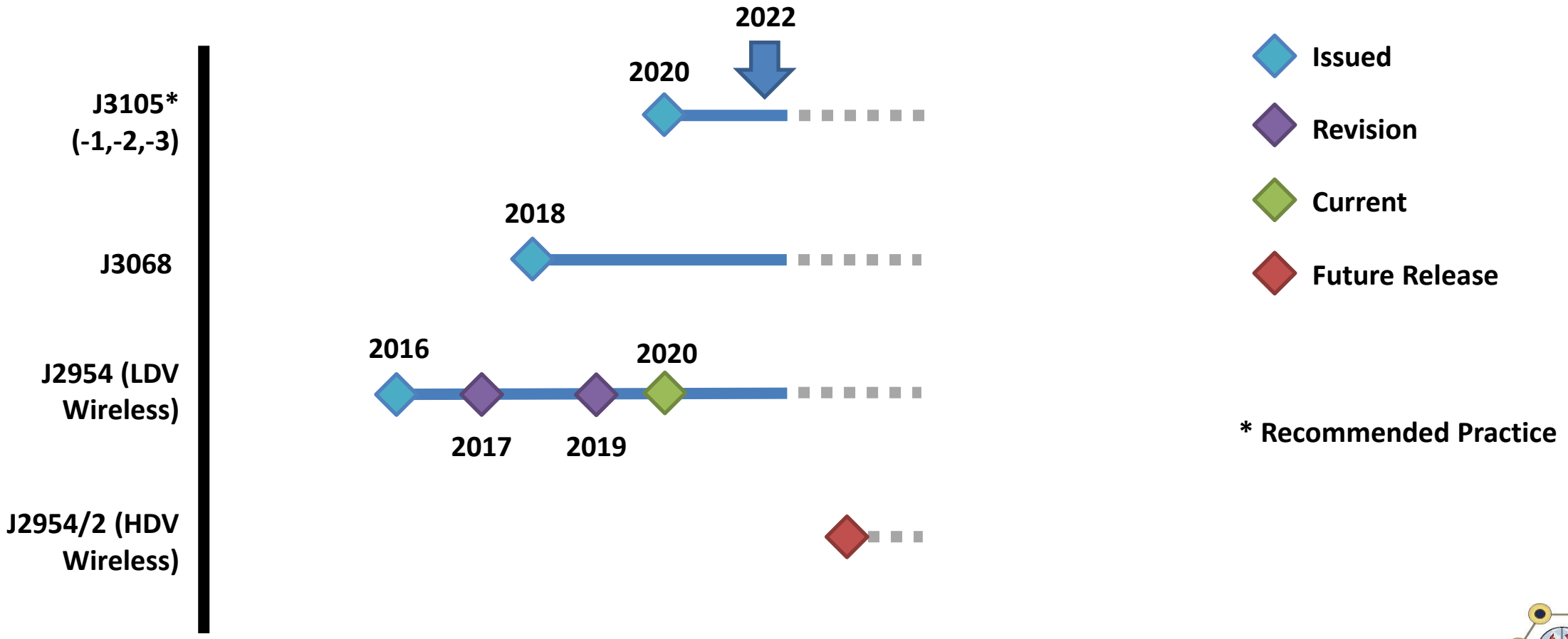
Status: Standards Timeline and Trajectories

Additional Standards for Consideration



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Status: Medium- and Heavy-Duty Charging Connectors

AC and Inductive EVSE Connector Market

	Current Standards							In Development
Connector	**GB/T 20234.2**	**IEC 60309**	**IEC 62196.2 (Type 2 - Mennekes)**	**IEC 62196.2 (Type 3 - Scame)**	**SAE J1772 (Type 1)**	**SAE J3068**	**SAE J2954**	**SAE J2954-2**
Current Type	AC	AC	AC[1]	AC	AC/DC[1]	AC	Inductive	Inductive
Power (kW)	14	10	Up to 33-43	Type 3A – 19.2 Type 3C – 43.6	AC: Up to 19.2 DC: Lvl 1- 80 kW Lvl 2 – 400 kW	Up to 133-166 kW	3.7, 7.7, 11, & 22 kW	Up to 500 kW
Voltage (V)	250/440	230	400/480 3/1ϕ	Type 3A – 230/240 Type 3C – 400	120/240 1ϕ, 208 3ϕ	480/600	N/A	N/A
Current (A)	16/32 (Rated 63)	15	63/70 3/1ϕ (Rated 300)	Type 3A – 32 1ϕ Type 3C – 63 3ϕ	80	160 3ϕ (Rated 300)	N/A	N/A
V2X						✓		
Markets	China	India	Europe	Europe (Now Deprecated)	North America, Japan	North America	North America	North America

[1]DC mode only implemented in Europe at Tesla Supercharger stations

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Status: Medium- and Heavy-Duty Charging Connectors

DC EVSE Connector Market

	Current Standards						In Development	
Connector	**CHAdeMO**	**GB/T 20234.3**	**CCS1**	**CCS2**	**Tesla (Proprietary)**	**SAE J3105[1]**	**SAE J3271 (MCS)**	**ChaoJi**
Current Type	DC	DC	AC/DC	AC/DC	AC/DC	DC	DC	DC
Power (kW)	6 – 400	187.5	Up to 350, Planned 450	Up to 350, Planned 450	AC: up to 19.2 DC: 250, 350 Planned	L1: up to 350 kW L2: up to 1.2 MW	Up to 3.75 MW	50-900 kW (Expandable)
Voltage (V)	1000	750	920, Planned 1000	920, Planned 1000	AC: 240 DC: 1000	Up to 1000	1250	1500
Current (A)	400	250	380 (Rated 500)	380 (Rated 500)	AC: 80A DC: 250, 350 Planned	Up to 1200	3,000	600
V2X	✓		WIP[2]	WIP[2]			✓	✓
Markets	Japan, Sporadic	China	North America	Europe	North America	North America, Europe	North America, Europe	China, Japan

[1]Recommended practice; [2] WIP = Work in Progress

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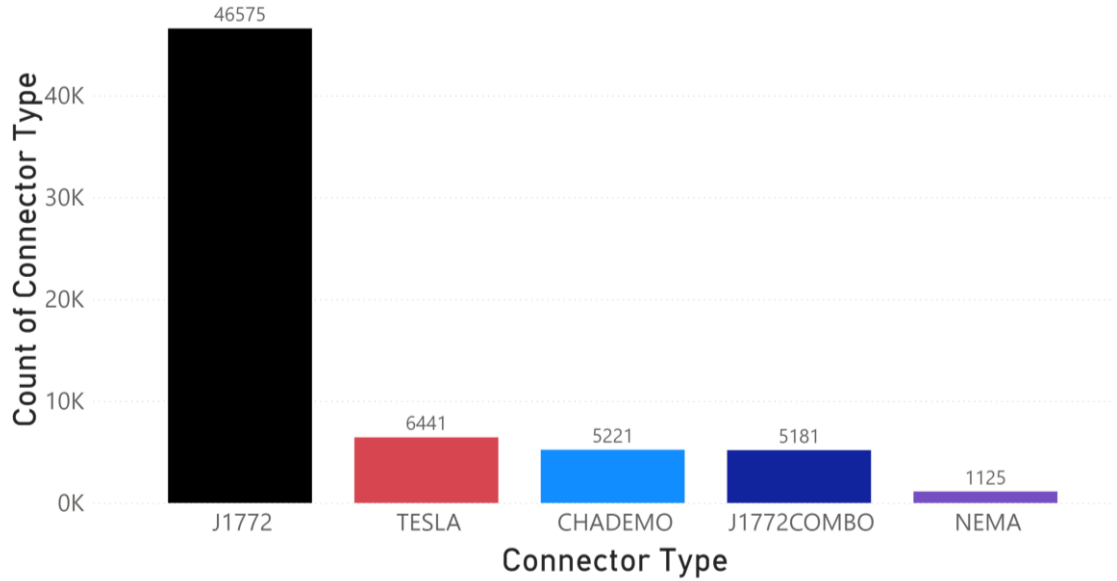
Status: U.S. Vehicle Markets for Charging Connectors

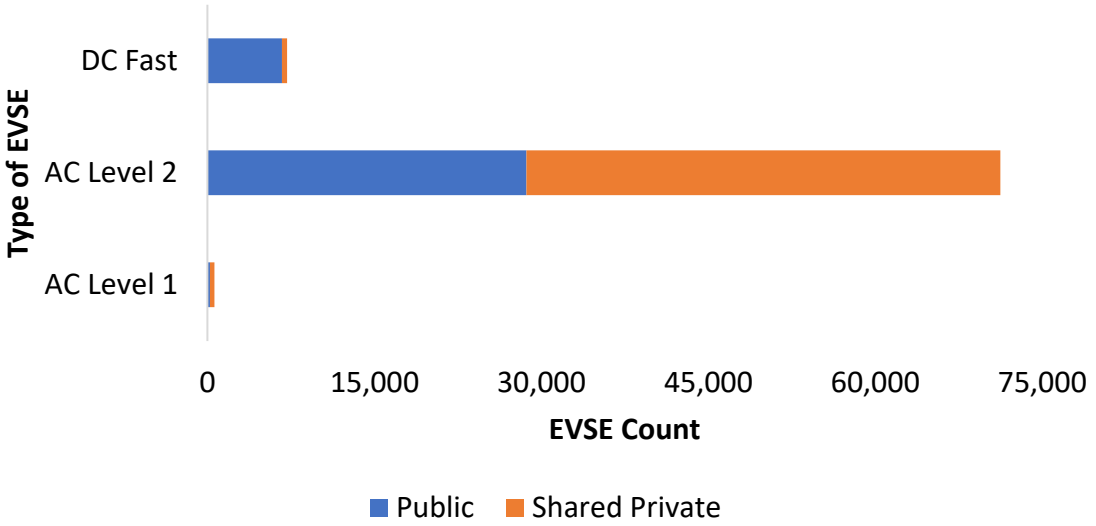
- EVSE connector types driven by light-duty market
- Within the U.S., LDV DC market is a mixture of CCS, CHAdeMO, and Tesla

U.S. Market Share of EVSE at Charging Stations by Connector Type



Data Extracted from US DOE Alternative Fueling Station Locator Oct 6th, 2021. * Some stations offer more than one connector type and are counted multiple times.

California Public and Shared Private EVSE by Charging Rate



Source: California Energy Commission (2022). Electric Vehicle Chargers in California. Data last updated January 31, 2022. Retrieved February 28, 2022, from https://www.energy.ca.gov/zevstats

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Status: U.S. Vehicle Markets for Charging Connectors

- **Charger selection dependent on:**
  - **Vehicle demand and EVSE cost**
  - **Public versus private stations: Fleets with on-site charging may still desire some public access for resiliency**

	Vehicle Category				
Connector Type	**Light-Duty**	**Bus**	**Class 3-5 Trucks**	**Class 6-7 Trucks**	**Class 8 Trucks**
J1772/CCS1	✓	✓	✓	✓	✓
J3068		✓	✓	✓	✓
Tesla	✓				*
CHAdeMO	^	^	^		
J3105		✓	*	*	*
J2954	+*				
J2954-2 (Wireless)		*	*	*	*
J3271 (MCS)		*	*	*	*

^Phasing Out
*Potential Future Market
+ Recently released

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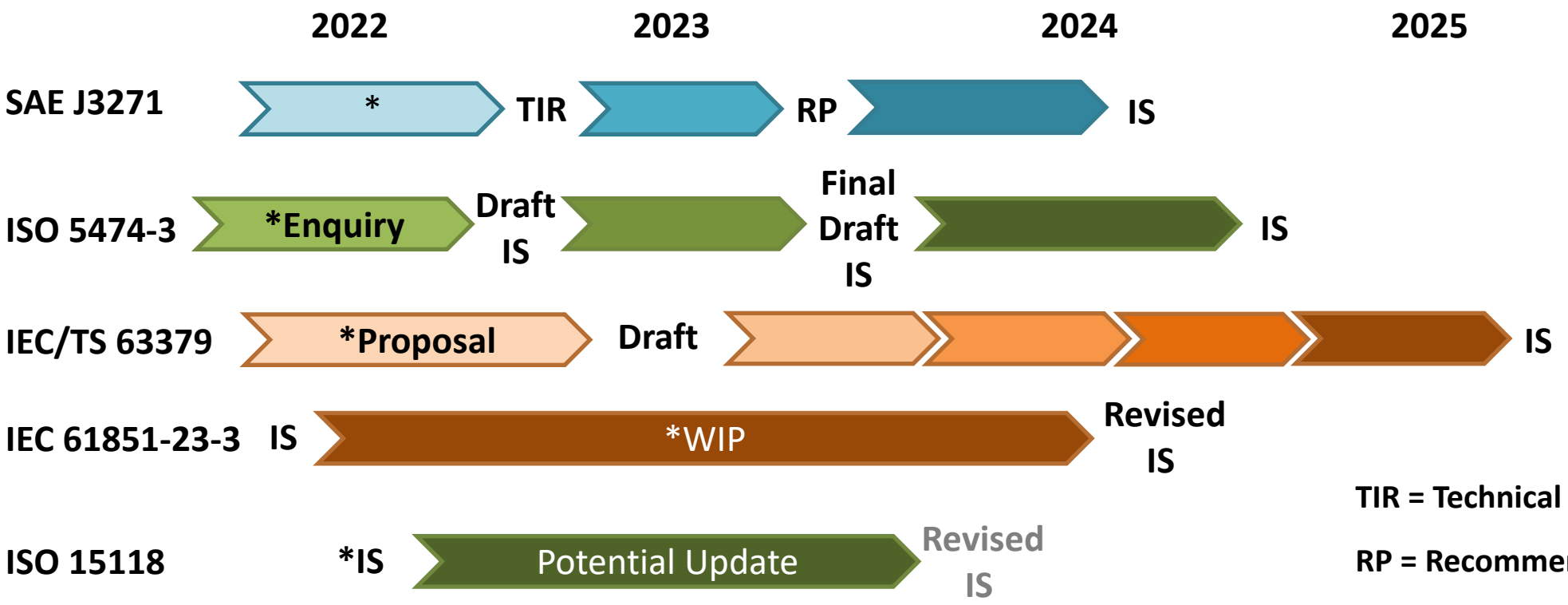
Status: Standards Pathways and Timelines

Megawatt Charging Timeline and Related Standards



TIR = Technical Information Report

RP = Recommended Practice

IS = International Standard

* Current Stage

Timelines are estimates

Source: Argonne National Laboratory, U.S. Department of Energy

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Status: Current Gaps

- **Topic areas directly related to codes and standards**
  - Charging rates
  - Reliability
  - Cybersecurity
  - Automated charging
  - Payment systems

- **Topic areas adjacent to codes and standards**
  - Station design
  - Public charging network buildout

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Status: Current Gaps and MHDV Charging Goals

Charging Rates

- **Lack of higher power charging**
  - **Type of Gap: Standards, Technology**
  - **MH-ZEV Gap Impact: Long charging times, possibly reduced vehicle availability**
  - **Recent Activities:**
    - **Standards**
      - **CCS planned update to 450 kW**
      - **Vehicle-side updates**
      - **Megawatt Charging System (MCS): CharIN, SAE J3271, Up to 3.75 MW**
    - **Battery Swapping**
      - **Alternative to higher charging rates to vehicles**
  - **Goal: Faster charging, vehicle operational parity (where feasible)**

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Status: Current Gaps and MHDV Charging Goals

Reliability

- **Currently, lower reliability than desired/needed***
  - **Type of Gap: Standards, Communication Protocol Implementation**
  - **MH-ZEV Gap Impact: Failed charging sessions, possibly reduced vehicle availability**
  - **Recent Activities:**
    - **Interoperability Testing**
      - **Increase compatibility between products in diverse market**
      - **CharIN: develop a more standardized approach for testing**
    - **Standards**
      - **CCS & ISO 15118**
      - **MCS (SAE J3271): Review communications protocols and target needs for MCS**
      - **WIP J3105/2**
      - **WIP J2954/2**
  - **Goals: Improved error resolution and overall higher reliability (99.9…%)**

*30-40% of charging sessions fail, Michael Paras, SAE International EV Charging Infrastructure Conference 2022

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Status: Current Gaps and MHDV Charging Goals

Cybersecurity

- **Risk for charging session disruption, tampering, and data insecurity (payment, fleet data)**
  - **Type of Gap: Standards, Communications Protocols**
  - **MH-ZEV Gap Impact: Risk for charging disruptions and data breaches**
  - **Recent Activities:**
    - **Standards/Protocol updates**
      - **ISO 15118-20, OCPP added Public Key Infrastructure (PKI) encryption (V1.8)**
    - **Best Practices**
      - **No exposed ports to access software/hardware, no standardized default passwords**
    - **Research**
      - **U.S. DOE Project (Concluded 2021): Securing Vehicle Charging Infrastructure – lack of encryption across inter-module communications**
      - **ElaadNL and the European Network for Cybersecurity (ENCS): set of cybersecurity requirements for charging stations**
  - **Goals: Improved station uptime and security**

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Status: Current Gaps and MHDV Charging Goals

Automated Charging (I/II)

- **Automated charging devices**
  - **Type of Gap:** Standards, Technology
  - **MH-ZEV Gap Impact:** High power systems can be safety risk
  - **Recent Activities:**
    - Standards
      - ISO 15118-20, ACDs - components supporting the automatic connection and disconnection process for conductive energy transfer between an EV and an EV supply equipment
      - SAE J3105
    - Industry development
      - Devices that utilize a combination of existing standards and proprietary hardware/software
  - **Goal:** Improved ease of use

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Status: Current Gaps and MHDV Charging Goals

Automated Charging (II/II)

- **Automated charging management**
  - **Type of Gap:** Standards
  - **MH-ZEV Gap Impact:** lack of charging reliability/flexibility resulting in sub-optimal charging performance
  - **Recent Activities:**
    - Standards
      - ISO 15118-20, Vehicle-to-grid
      - J3271 (MCS), currently reviewing communications protocols to identify needs
  - **Goals:** Greater charging reliability and flexibility

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Status: Current Gaps and MHDV Charging Goals

Payment Systems

- **Lack of standardization is a current barrier to public charging access/use**
  - **Type of Gap: Codes and Standards, Policy**
  - **MH-ZEV Impact: Use of a variety of subscription plans and payment systems can limit customer access and use**
  - **Current CA Law: SB 454 Electric Vehicle Charging Stations Open Access Act (2013)**
    - Encompasses transparency and consumer choice requirements, including station location, pricing, and interoperable payment methods across networks
  - **Recent Activities:**
    - CARB
      - Standards technology review report released in February 2022: real and perceived barriers exist, including interoperability, payment methods, and membership requirements
    - CharIN
      - Position paper on payment systems
  - **Goals: Ease of use and broad utilization of a public charging network**

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Status: Current Gaps

- **Topic areas directly related to codes and standards**
  - **Charging rates**
  - **Reliability**
  - **Cybersecurity**
  - **Automated charging**
  - **Payment systems**

- **Topic areas adjacent to codes and standards**
  - **Station design**
  - **Public charging network buildout**

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Status: Topic Areas Adjacent to Codes and Standards

Station design:

- **Need to consider different vehicle classes and duty cycles**
  - **Number and type of chargers, layout, ingress, egress, mix of vehicles charging, etc.**

Source: CALSTART 2021 Taking Commercial Fleet Electrification To Scale: Financing Barriers and Solutions

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Status: Topic Areas Adjacent to Codes and Standards

Station design:

- **Need to consider different vehicle classes and duty cycles**
  - **Number and type of chargers, layout, ingress, egress, mix of vehicles charging, etc.**

- **Selecting charging power often an economic decision**
  - **Significant cost difference between 19.2 kW and 50 kW, 150 kW and 350 kW**

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Status: Topic Areas Adjacent to Codes and Standards

Public charging network buildout

- **Public stations can support fleets by supplying fleets without on-site charging and supplementing fleets that have on-site charging**

	Vehicle Category				
Connector Type	**Light-Duty**	**Bus**	**Class 3-5 Trucks**	**Class 6-7 Trucks**	**Class 8 Trucks**
J1772/CCS 1	✓	✓	✓	✓	✓
J3068		✓	✓	✓	✓
Tesla	✓				*
CHAdeMO	^	^	^		
J3105		✓	*	*	*
J2954	+*				
J2954-2 (Wireless)		*	*	*	*
J3271 (MCS)		*	*	*	*

Options for MHDV Public Stations?

^Phasing Out
*Potential Future Market
+ Recently released

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Status: Summary of Initial Findings

- **Initial Consensus**
  - **Harmonized approach**
    - **Reduce market heterogeneity of standards**
      - **consider charging rate and cost**
    - **Improved reliability**
    - **Faster charging rates**
  - **A range of charging rates are needed to meet MHDV operational needs**
    - **Level 2 charging may be sufficient for some vehicle classes and applications**
    - **DC fast charging up to megawatt charging can provide greater operational flexibility**
  - **Public versus fleet charging stations**
    - **Fleets may opt for modular approach for expanding infrastructure in pace with MH-ZEVs**
    - **Public network may serve as backbone for fleets, providing resiliency**
      - **Standardized charging infrastructure can support broad use of a public charging network**

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Discussion Questions (I/III)

1. What additional charging infrastructure standards gaps and/or performance gaps need to be addressed to support large-scale deployment for MH-ZEVs?

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Discussion Questions (II/III)

2. What specifications are appropriate to guide those applying for charging station grant awards?

- **Are there any ambiguity or issues with current funding solicitations?**
- **Listing standards/certification/testing requirements?**
- **Referencing a TIR (Technical Information Report) pre-standard**
- **Guidance for Demonstrations**

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Additional Discussion Questions (III/III)

1. **Should public funding requirements vary for fleet (private) versus public charging stations?**
   - **Codes and standards**
   - **LDV and HDV shared access**

2. **What are the current limitations holding back the widescale deployment of a MHDV charging network?**

3. **Are there additional topics/issues that you would like to see in the second interim report?**

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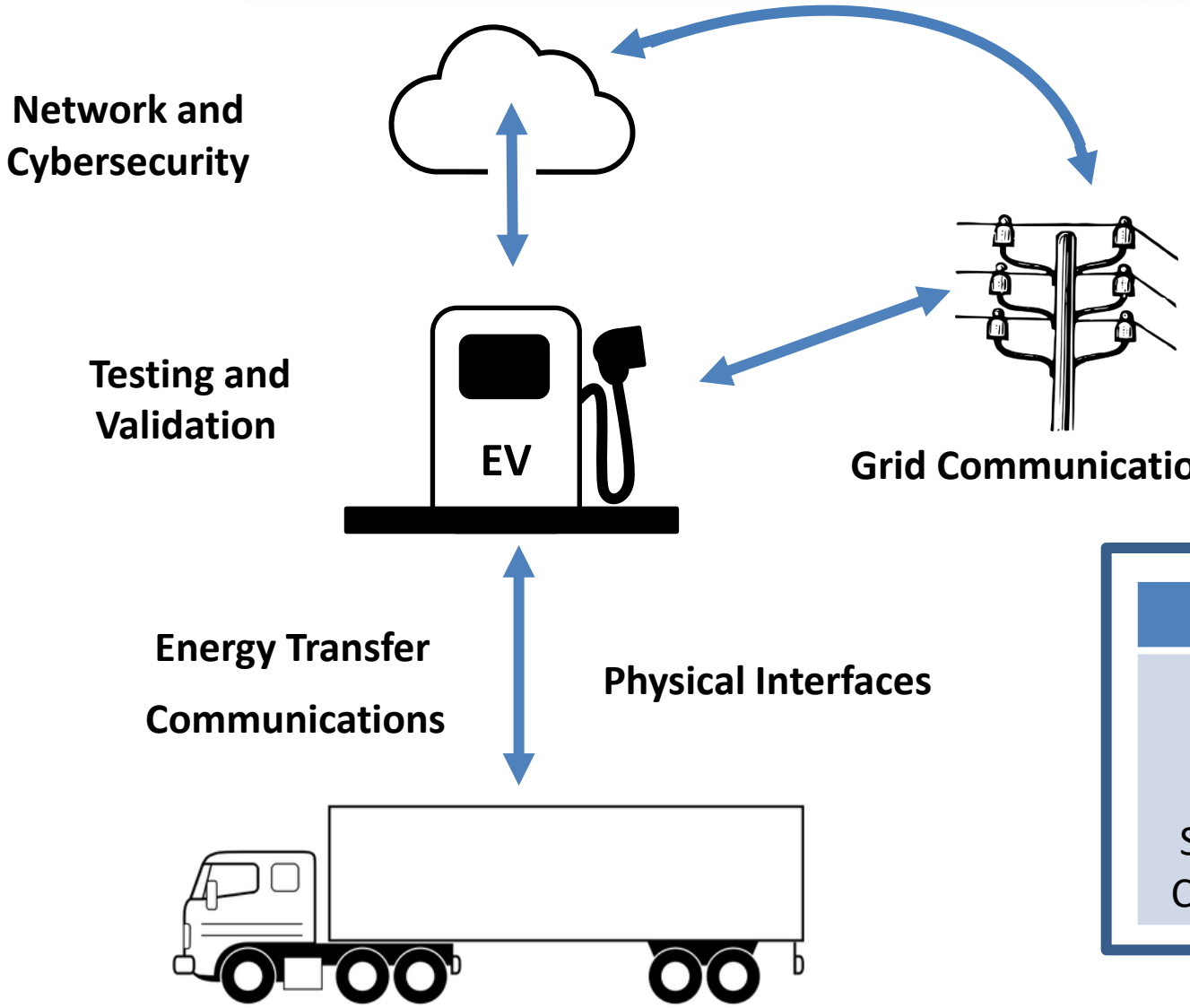
Next Steps



White Paper
Analysis of Findings
Policy Recommendations

Year 1 Topics	Year 2 Topics
Current Market	**(Grid) Communications**
Energy Transfer	**Testing and Certification**
Physical Interfaces	**Network and Cybersecurity**
Standardization Efforts	Policy Actions
Current Standards Gaps	

Interim Report 1 **Interim Report 2**

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Next Steps

- **Finalize list of *current* federal and state government actions related to supporting the standardization of MH-ZEV infrastructure deployment**
- **Finalize list of *possible* federal and state government actions related to supporting the standardization of MH-ZEV infrastructure deployment**

What actions should the state and/or federal government take to support standardization and accelerate the MH-ZEV infrastructure network buildout?

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Next Steps

- **Continue examining current standards and technologies development**
  - International efforts, Optimization within existing standards, Testing, Communications protocols
  - Timeline: September 2022
- **Engage key stakeholders and integrate stakeholder input**
  - Drive towards consensus
- **Further refining of policy actions and timeline**
  - Specificity, Timing
  - Timeline: White paper January 2023

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Project Final Product – White Paper

- **White Paper Goals:**
  - **Synthesize the background, research, interviews, and findings of the project**
  - **Identify standardization gaps, pinch points, and priority areas that are critical for the market success of MH-ZEVs within the State**
  - **present policy recommendations and high-level guidance based on the assessments conducted**
  - **propose additional assessments necessary to facilitate MH-ZEV adoption and protect investments in a zero-emission transportation future**

- **Draft White Paper – January 2023**

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Written Comments

http://www.apep.uci.edu/**MHDV**_Protocol_Comment.html

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