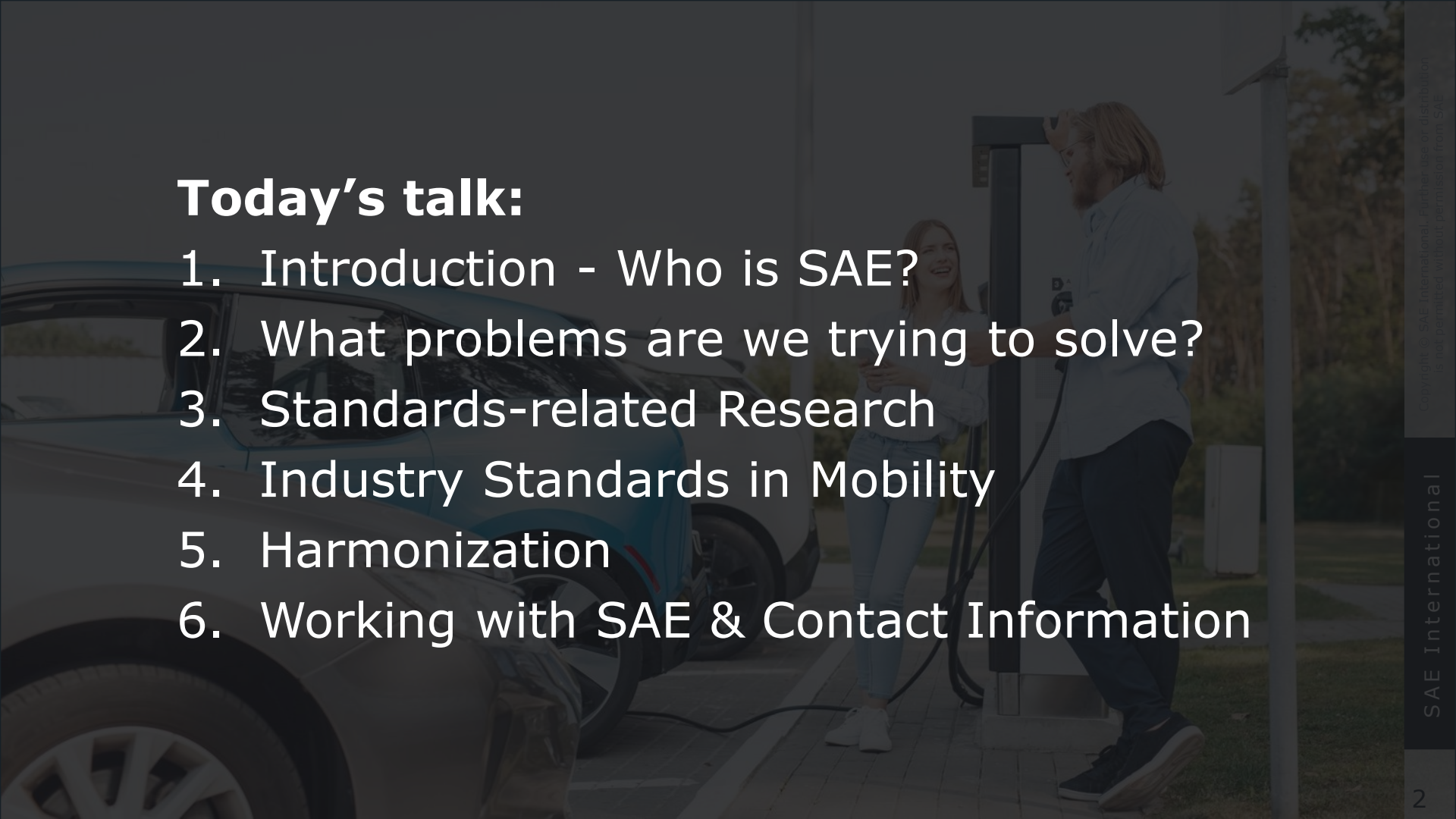
SAE and Technologies to Support Resilience: An Overview

Smoky Mountains Mobility Conference 2024

Dr. Edward Straub, Director, SAE Office of Automation



Today's talk:

1. Introduction - Who is SAE?
2. What problems are we trying to solve?
3. Standards-related Research
4. Industry Standards in Mobility
5. Harmonization
6. Working with SAE & Contact Information

Who is SAE?

Mobility, Advanced™

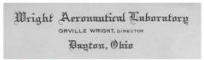
Our History

Mobility, Advanced™

1905
SAE® is founded in New York City

1906
First SAE technical meeting

1912
First SAE Standard published



1916
Orville Wright becomes a member of SAE

1917
First SAE aerospace standard published

1936
First SAE National Aircraft Production Meeting

1974
SAE moves headquarters to Warrendale, PA

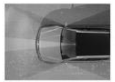
1976
Collegiate Design Series established with Mini Baja event

1986
SAE Foundation℠ formed

1990
A World in Motion® is established as science program for 4th-6th grade students

2009
SAE J1772™ Standard released defining charging connector for electric vehicles

2014
SAE J3016™ Standard released defining levels of automated driving



2018
SAE partners with industry to advance hybrid/electric aircraft propulsion

2019
SAE and industry partners form AVSC™ to address autonomous vehicle safety

2024
SAE partners with industry EV leaders to publish J3400 standardizing EV physical connector

Advancing Mobility Across the Globe

200,000+
members & volunteers

90 Countries
42 Sections
115 Student Chapters

North America:
Pittsburgh
Washington, DC
Silicon Valley
Detroit

Europe:
Amsterdam
London

Asia:
Shanghai

Global Affiliates
SAE Brasil
SAE India

MISSION: To advance mobility knowledge and solutions for the benefit of humanity

Mobility, Advanced℠

Community Engagement

Over **200,000** professional members and volunteers in **90** countries. **42** member sections. **115** student chapters.

Training & Development

12,000 technical professionals annually attend our **200** classroom courses, **35** web seminar titles and multiple on-demand classes.

STEM Programming

PreK-College STEM programs utilized by **100,000+** students yearly.

Events

Over **70+** in person global technical events annually and **30+** virtual events for the aerospace, automotive, off-highway, and related mobility industries.

SAE INTERNATIONAL

Media

13 magazines, **19** eNewsletters, podcasts, webinars, custom publishing

Technical Content

Repository of **151,700+** technical papers with **~2200** published annually, **1000** technical standards annually, plus over **500** book titles all accessible through SAE Mobilus.

Technical Standards

More than **44,000** aerospace and ground vehicle standards.

Foundation

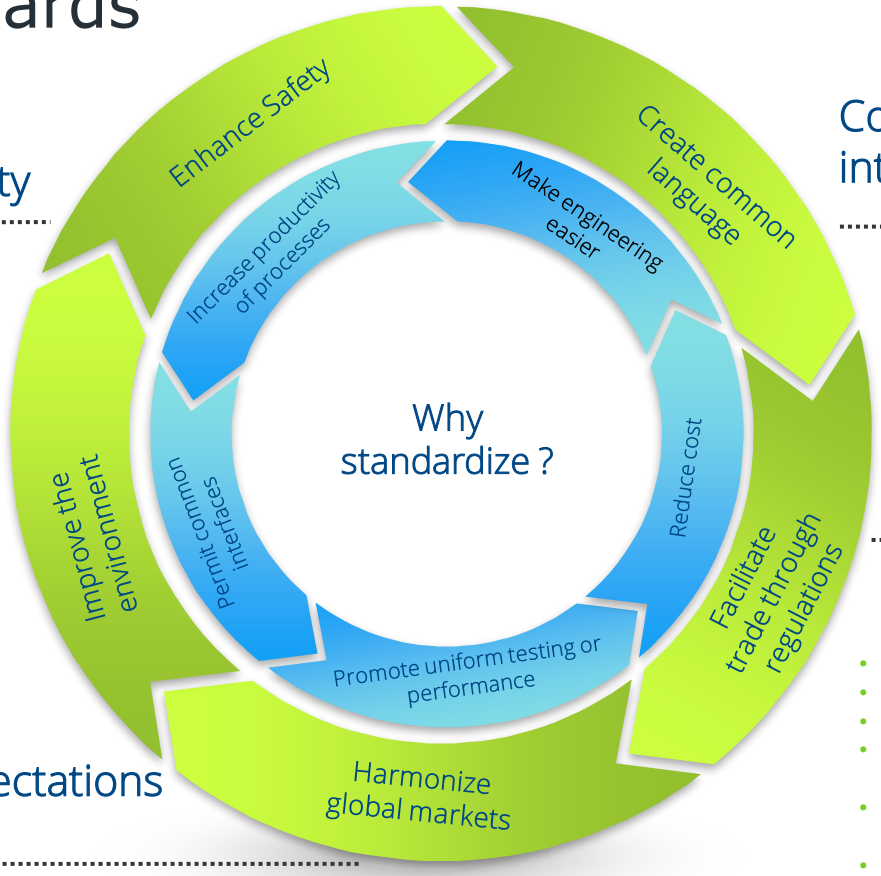
Funds raised provide **100,000** PreK – 12 students with access to STEM programming each year and honor the best and brightest students, teachers, and industry professionals with awards and scholarships.

Role of Standards

Consistent product quality

Regulatory compliance foundation

Consistent and clear expectations for product performance



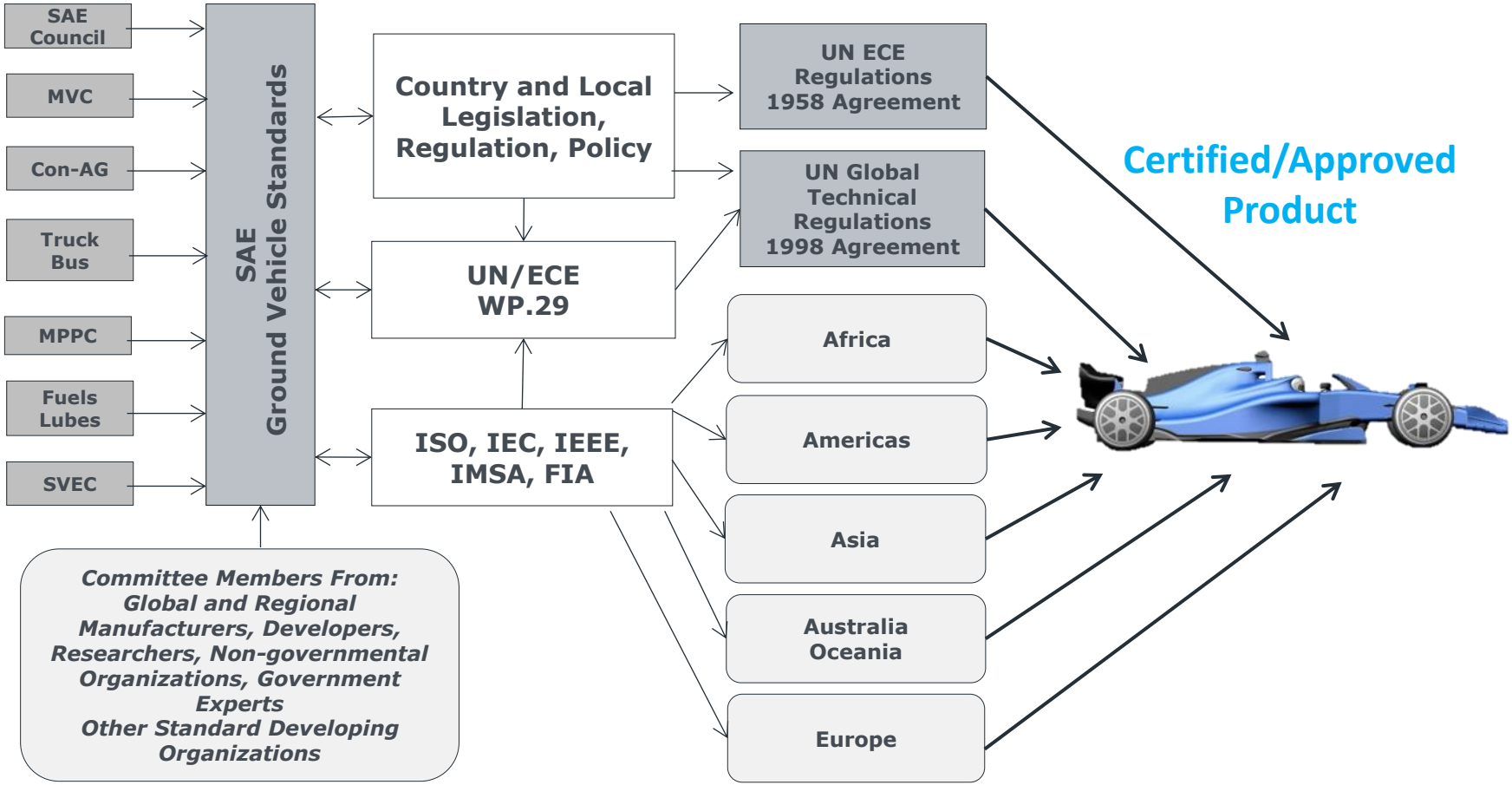
Compatibility and interoperability

More efficient procurement

- ***Lowers trade barriers***
- ***Lowers purchasing costs***
- ***Decreases design time***
- ***Increases new technology speed to market***
- ***Promotes innovation and fosters competition***
- ***Advances the collective technology of industry***

https://www.sae.org/

SAE Standards – Product Impact & Incorporation



1,000+ SAE Standards

currently cited in international regulations

NHTSA	EPA	U.S. Department of Labor MSHA Mine Safety & Health Administration	U.S. Department of Housing and Urban Development	Consumer Product Safety Commission	Federal Trade Commission
232	87	42	3	1	1

OSHA	FMCSA	United States Coast Guard	Federal Aviation Administration	EASA European Aviation Safety Agency	ICAO
40	21	24	402	150	60

Relevance to CET

Critical and emerging technology areas:	Direct	Indir.
Advanced Computing	X	
Advanced Engineering Materials		X
Advanced Gas Turbine Engine Technologies		
Advanced Manufacturing	X	
Advanced and Networked Sensing and Signature Management	X	
Advanced Nuclear Energy Technologies		
Artificial Intelligence	X	
Autonomous Systems and Robotics	X	
Biotechnologies		

Critical and emerging technology areas:	Direct	Indir.
Communication and Networking Technologies		X
Directed Energy		
Financial Technologies		X
Human-Machine Interfaces	X	
Hypersonics		
Networked Sensors and Sensing	X	
Quantum Information Technologies		
Renewable Energy Generation and Storage		X
Semiconductors and Microelectronics		X
Space Technologies and Systems		

Challenges in an Evolving Industry

Broad Drivers / Influencers

Industry Technology Focus:

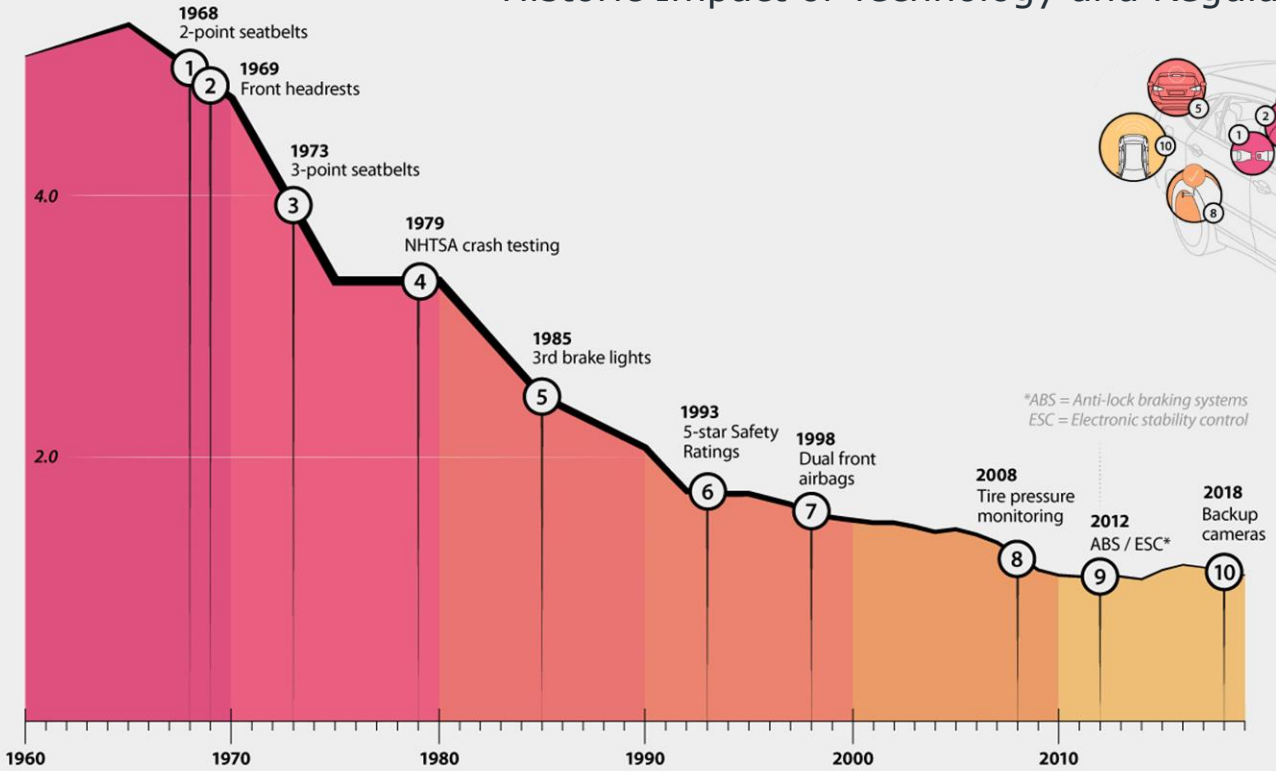
- **Environment – Decarbonization**
  - EV / Hybrid Technology
  - Battery Tech / Traceability – "Battery Passport"
  - Alternative Propulsion i.e., Hydrogen
  - Digital Infrastructure
- **Safety**
  - ADAS / Automated / Connected Car / V2X
  - Infrastructure
  - Micromobility

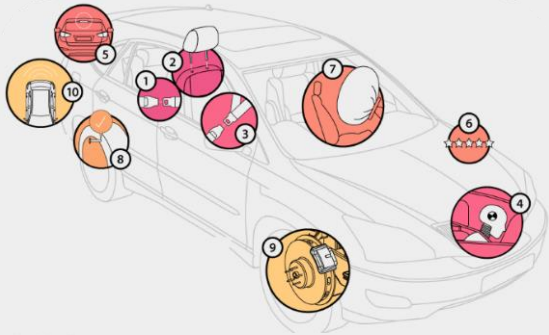
Geo-Political Climate:

- **Raw materials**
- **Vulnerable supply chain**
  - Tariffs
  - Legislation

Safety Challenge

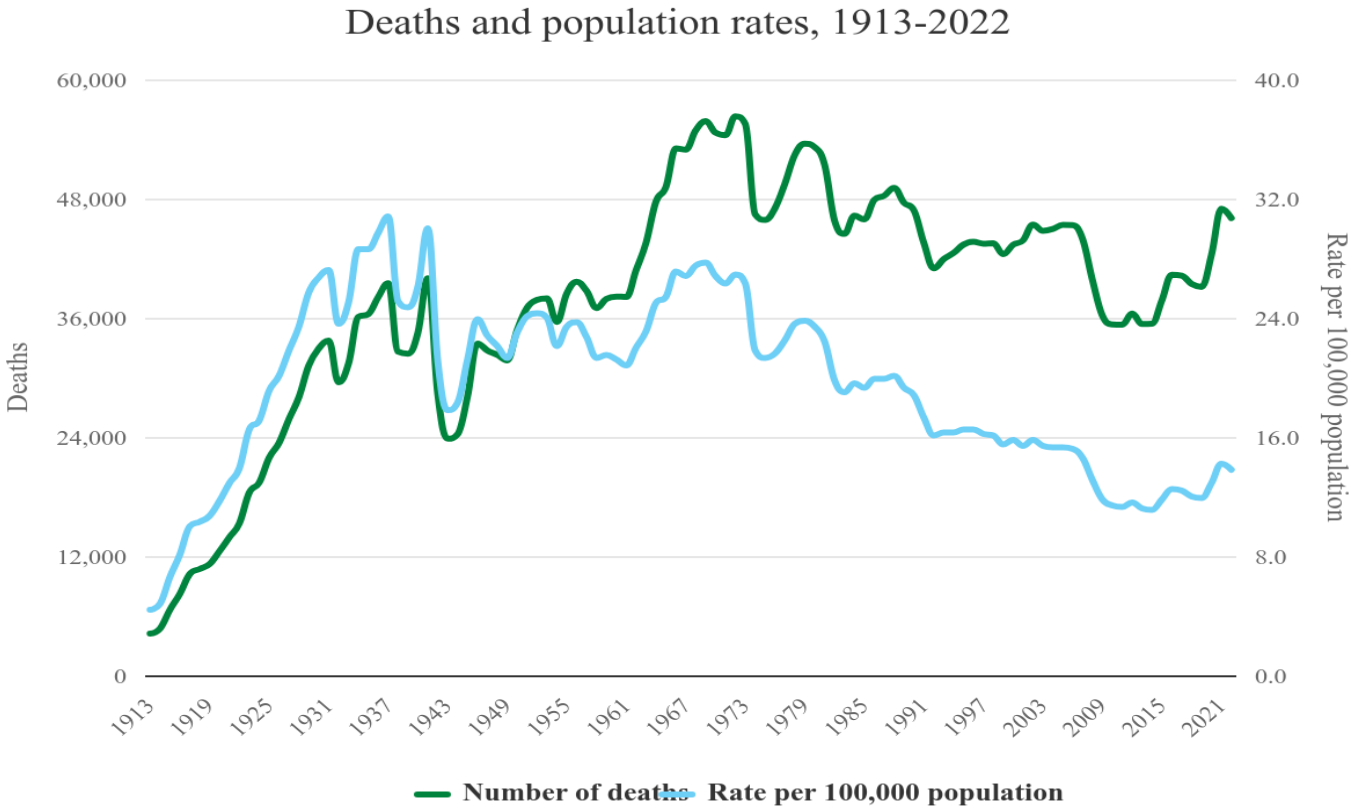
Historic Impact of Technology and Regulation





https://www.visualcapitalist.com/how-has-car-safety-improved-over-60-years/

Traffic Fatalities



US vs OECD

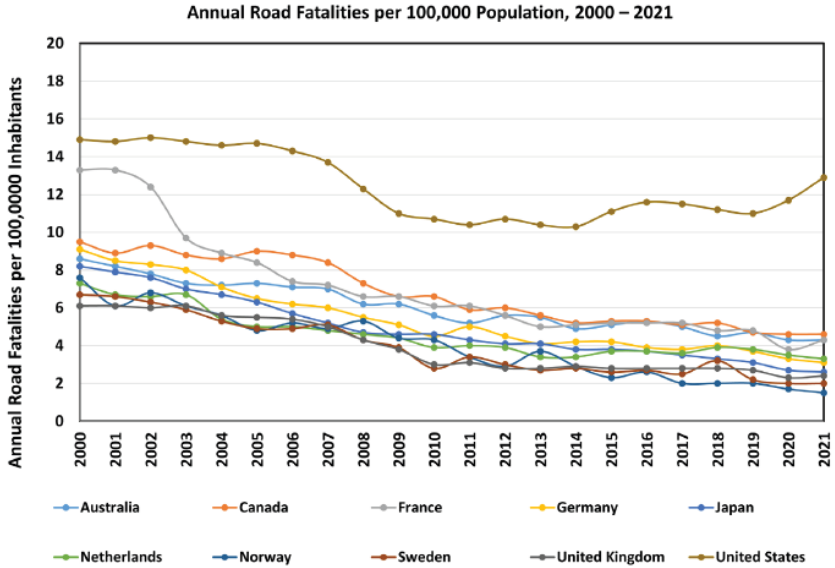


FIGURE 2-1 Motor vehicle fatalities per 100,00 population for selected countries.
SOURCE: Data from OECD/ITF Annual Road Safety Reports. https://www.itf-oecd.org/node/28195.

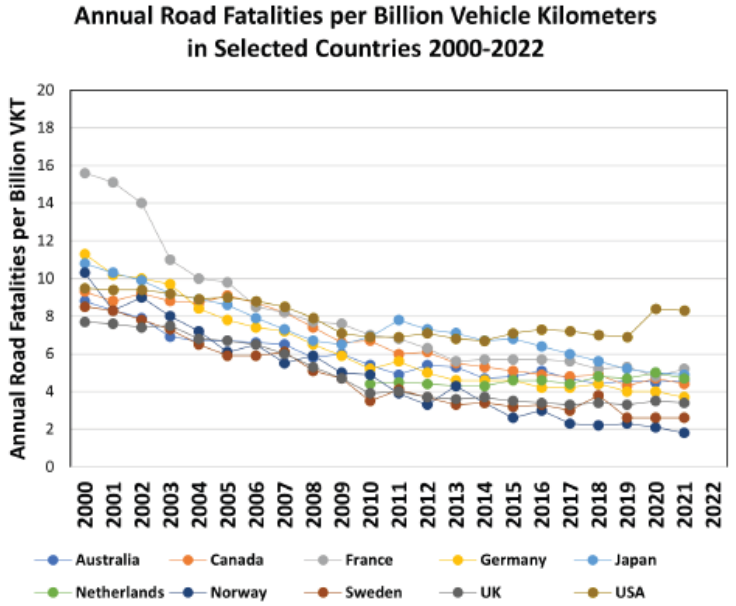
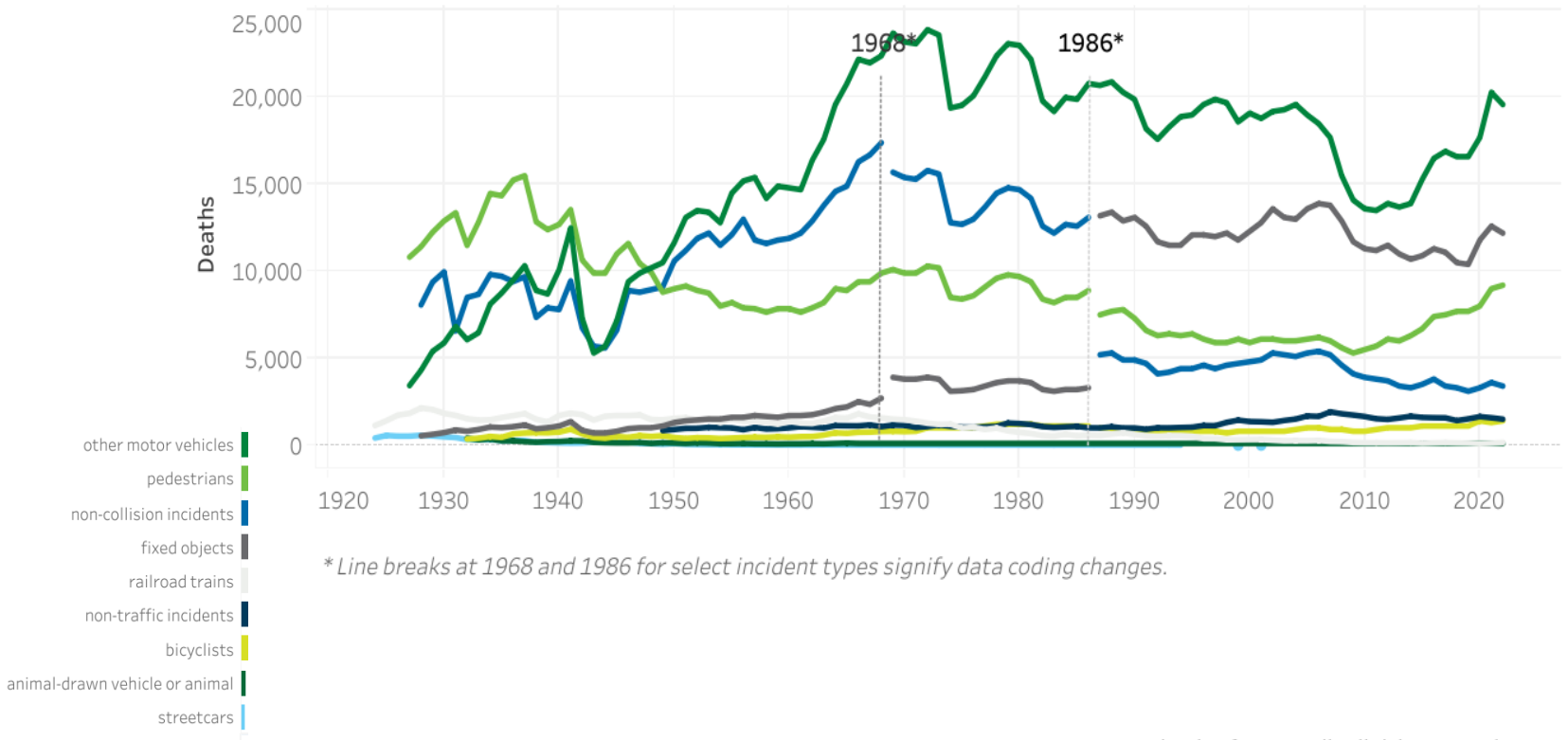


FIGURE 2-2 U.S. road death rate per billion vehicle kilometers versus other countries.
SOURCE: Data from OECD/ITF Annual Road Safety Reports. https://www.itf-oecd.org/node/28195.

SOURCE:
National Academies of Sciences, Engineering, and Medicine. 2024. *Tackling the Road Safety Crisis: Saving Lives Through Research and Action*. Washington, DC: The National Academies Press. https://doi.org/10.17226/27804.

Fatalities by Category



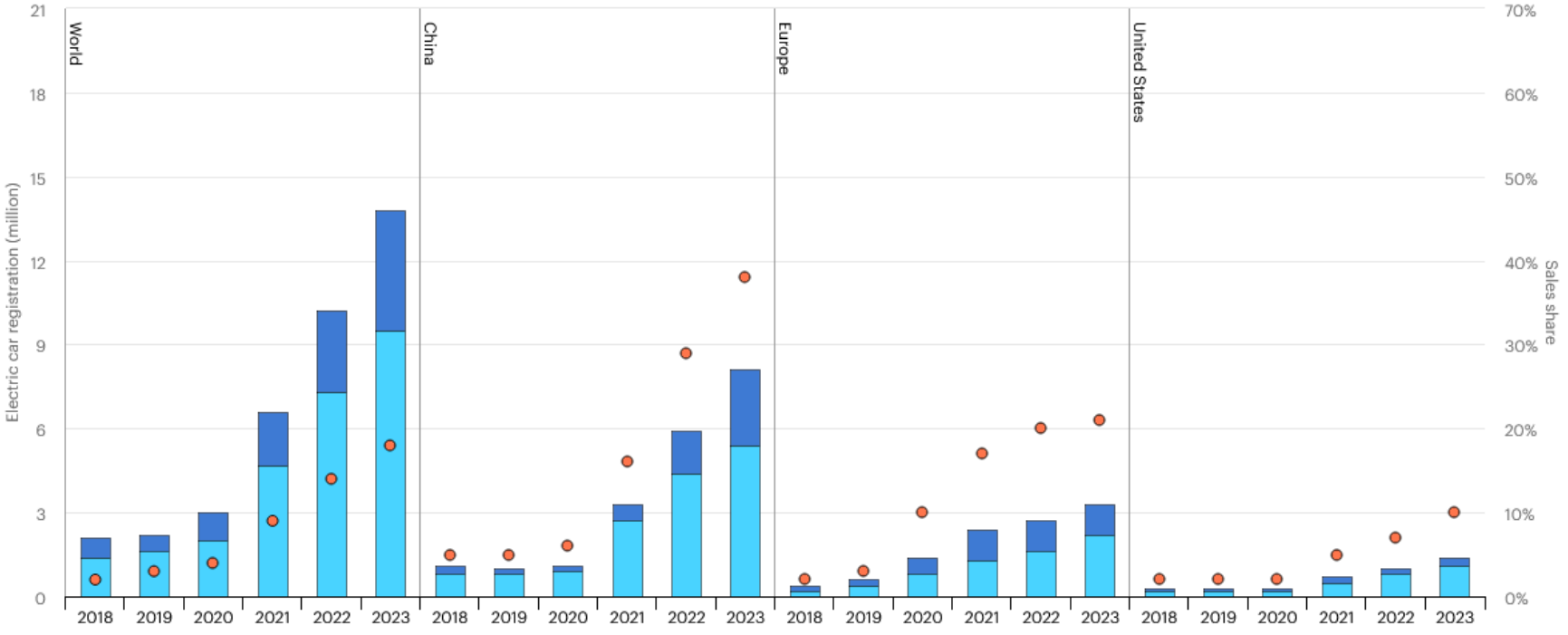
** Line breaks at 1968 and 1986 for select incident types signify data coding changes.*

Electric Vehicle Challenge

- Global automakers scaling down electrification targets
- Some drivers:
  - Cost
  - Slow roll-out of charging points
  - Growing trade tensions
  - Increased competition
- Slower than expected sales growth
  - Global EV sales (BEV or PHEV) rose 20% in the first half 2024, slower than expected
- Only 1% EV sales growth in first half 2024 in Europe

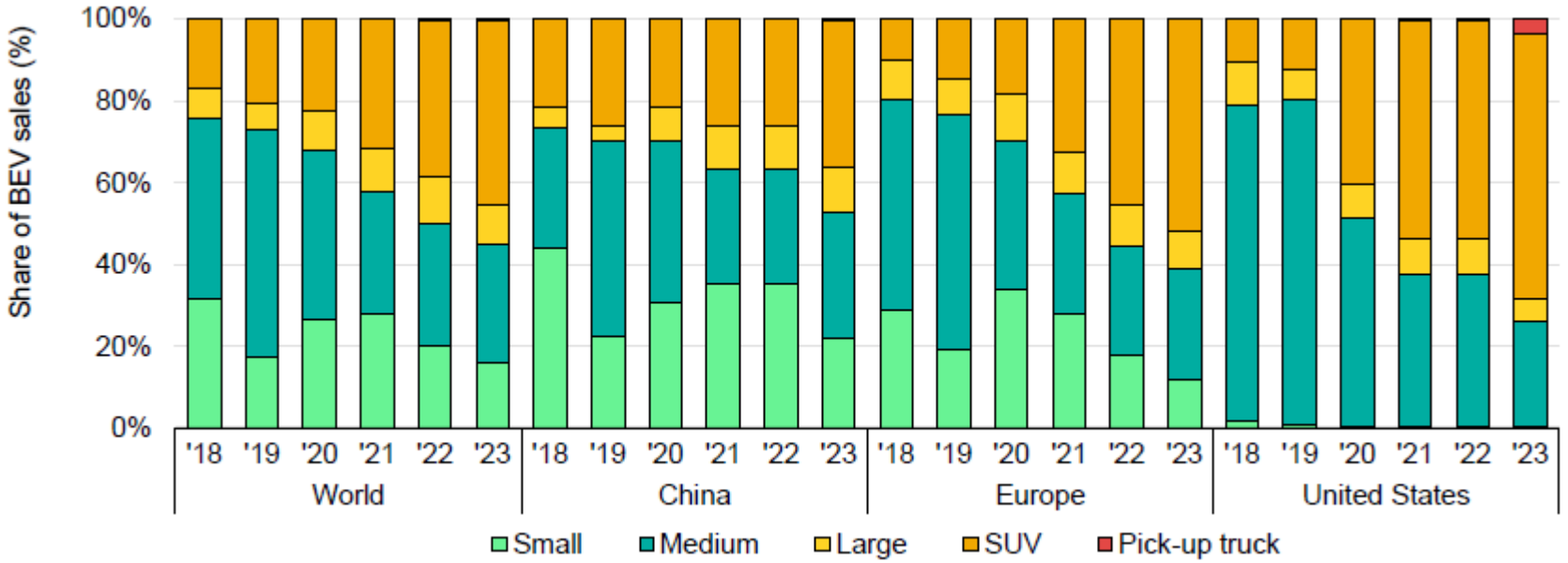
Source: https://www.reuters.com/business/autos-transportation/carmakers-adjust-electrification-plans-ev-demand-slows-2024-09-06/

EV Registrations in China, Europe, and U.S.



Source: IEA (2024), Global EV Outlook 2024, IEA, Paris
https://www.iea.org/reports/global-ev-outlook-2024, Licence: CC BY 4.0

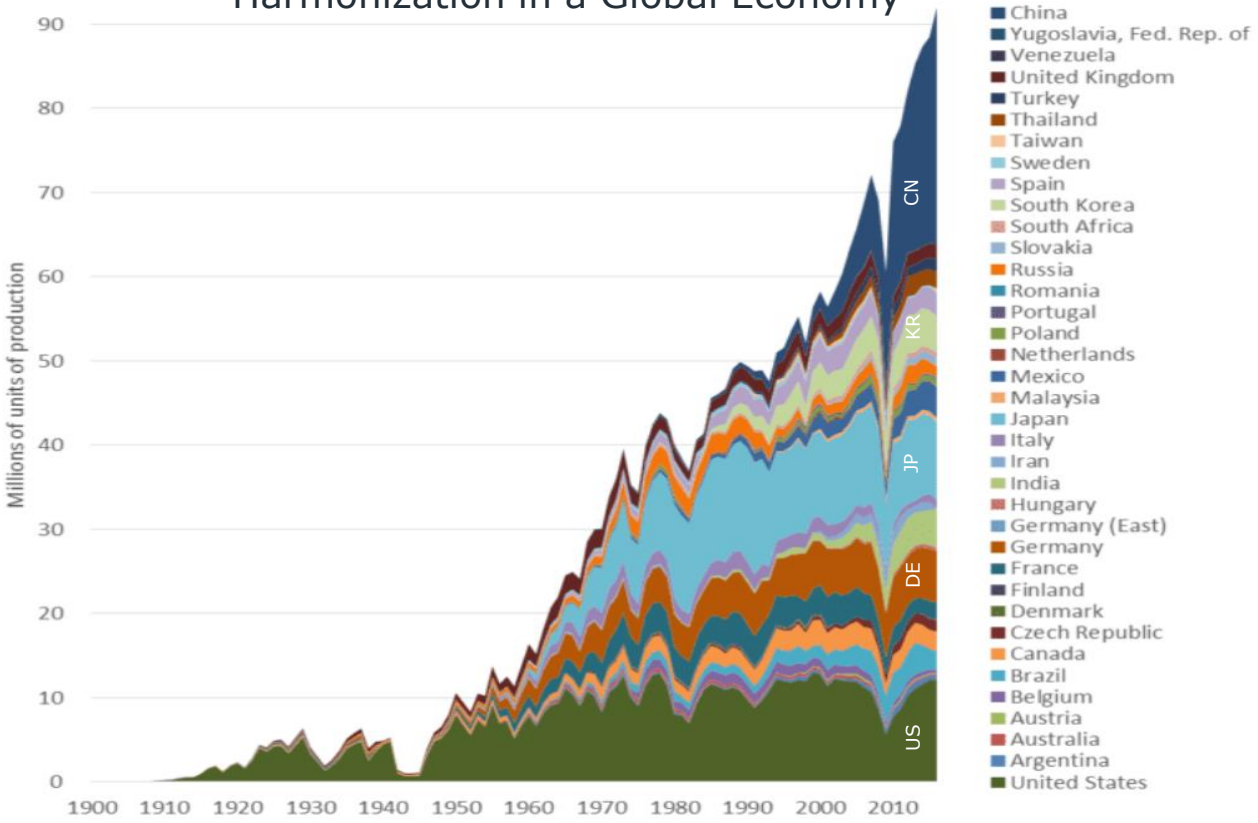
BEV Sales by Type & Region



Source: IEA (2024), Global EV Outlook 2024, IEA, Paris https://www.iea.org/reports/global-ev-outlook-2024, Licencs: CC BY 4.0

Supply Chain Challenge

Harmonization in a Global Economy



Graph sources: Motor Vehicle Manufacturers Association of the United States, *World Motor Vehicle Data*, 1981 Edition; Ward's Communications, *Ward's World Motor Vehicle Data 2002*; United States Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics*, Table 1-23 [https://www.darrinqualman.com/global-automobile-production/]

Workforce Challenge

shortages & talent gaps throughout the value chain and at all levels

In the battery workforce alone, more than **700 new job types** will come into play and up to **400,000 new battery jobs in the US** will be created by 2030.

New skills needed at every level of the workforce

Operators & technicians: advanced manufacturing, working on and servicing high voltage systems, safe handling raw materials, automation and robotics – critical for building and deploying

Engineering: electro- & battery chemistry, module/pack design, BMS, scaling manufacturing w/ stringent QA & process controls, systems engineering, sustainability and safety

Leadership: advanced manufacturing, deep engineering & supply chain knowledge, market opportunities, policy, regulations, sustainability/circularity and traceability

How to address these challenges?

Near-term fixes to quickly address current workforce shortages

Long-term solutions to close the gap in the labor pool

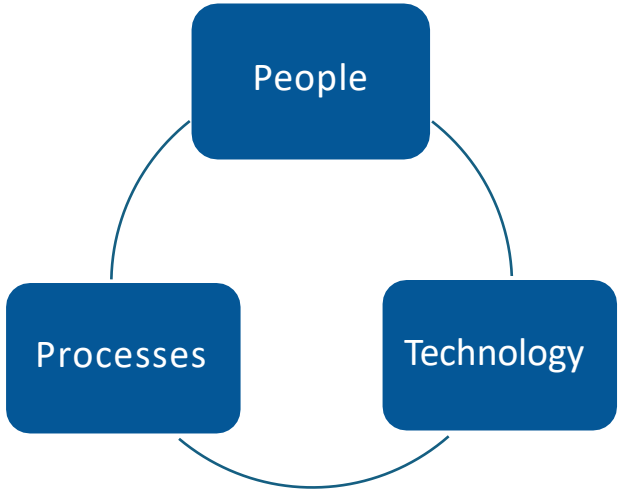
Battery Manufacturing

1. Workforce shortages & need for new models to address demand

- Current shortages across STEM – lack of engineers, technicians and operators with battery-electric knowledge; drastic need to reskill/upskill
- Few K-12 and higher ed learning pathways related to batteries and electrification – will lead to future shortages

2. Balancing compliance and production in a rapidly evolving landscape a real challenge

- Opaque supply chains (ensuring ethical, sustainable and safe production)
- Tightening regulations and changing policy can drive significant financial impact



3. Lack of standardization hindering speed or scale

- Rapidly evolving technology means a lack of standardization across every part of the value chain

Materials

- EV battery demand greatest contributor to increasing global demand for critical metals
- Battery demand in 2023
  - Lithium ~140 kt (30% incr from 2022)
  - Cobalt ~150 kt (15% incr from 2022)
  - Nickel ~370 kt (30% incr from 2022)
- Geo-political issues
- Extraction / environmental challenges
- Cost

Source: IEA (2024), Global EV Outlook 2024, IEA, Paris https://www.iea.org/reports/global-ev-outlook-2024, Licencs: CC BY 4.0

SAE Ground Vehicle Technology Focus Areas

Where We're Going

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Automation

- Modularity: Develop scalable systems
- Clarification of ADAS Levels
- Education regarding tech advancements

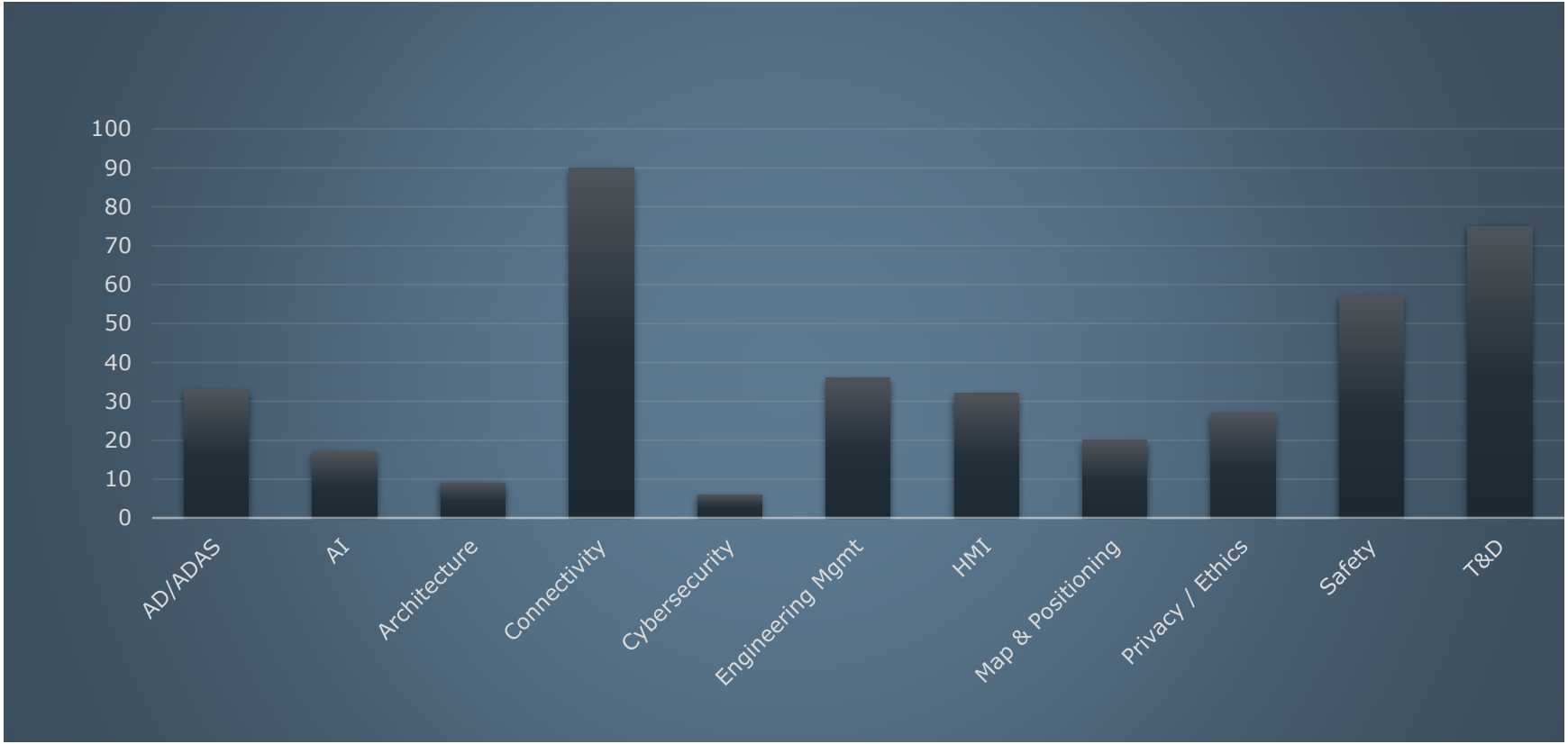
Sustainability

- EV Charging Infrastructure
- Battery Lifecycles
- Workforce Development
- Alternative Fuels

Advanced Manufacturing

- Standardization
- Certification
- Solve supply chain challenges
- Facilitate industry connections

Global Standards by Topic



SAE Standards-Related Research

SAE Cooperative Research (CRP)

CRP is a joint venture project where numerous organizations pool their resources to study a pre-competitive technical area where results are shared by the participants.

Customized to support standards initiatives: before (acquire needed data), during (test assumptions of performance levels), and after (validate the standards or products made to the standards)

2024 CRPs

- **Functional Safety Phase 3**. Next 5-year update for SAE J1939-76 required due to corrected calculations and enhanced language for useability of this communications protocol.
- **Wireless Power Transfer – Phase 2**. This research will conduct Heavy-Duty Dynamic EMC and EMF Testing of wireless power transfer technology (both Dynamic and Static). The goal is to experiment with new hardware and techniques, along with the optimized frequency of operation.
- **Next Gen Tractor Trailer Connector**. Research is needed to replace the current SAE J560, 7-way connector to support future tractor trailer communications. Review multiple connector system approaches and create the best option (moving away from 12V Systems to 24V) with new communication protocols.
- **Thermal Refrigerant Management CRP**. A multi-year, multi-phased project with multiple SubTeams performing research specifically for new refrigerants and new/optimized architectures in Mobile Air Conditioning Systems. Targeted toward BEV's and heat pump systems.
- **IMAC-TMR-LCCP Modeling Tool**. Running parallel with the Thermal Management Refrigerant CRP, this software tool supports Thermal Management, Life Cycle Climate Performance of MAC systems and provide battery life estimates for ICE or Electric vehicle comparisons range and power usage.
- **SAE J1939-91C Network Security - Phase 1 / Phase 2**. SAE J1939-91C defines recommendations for secure on-board communications between ECU's within a vehicle itself, no external interfaces or connections.
- **FMVSS-141 Measurement Uncertainty**. This research evaluated sources and the amount of measurement uncertainty in the test procedures of FMVSS-141 (updating test procedures and approach within SAE J2889-1 and ISO 16254)

Research: Connectivity

V2X as a resource conceptual hierarchy

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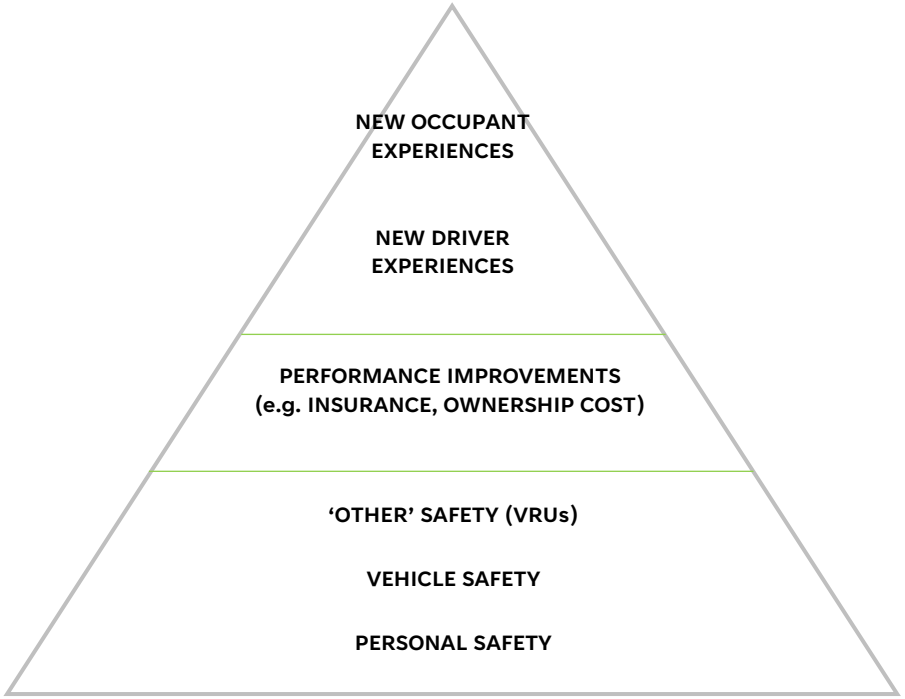
Second level
MONETIZABLE opportunities

Baseline user
expectations



V2X as a Resource

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PRE-COMPETITIVE / ENABLING PLATFORM

SAFETY

EFFICIENCY

Safety and efficiency reside in the pre-competitive V2X space. This could incent the OEMs to agree on standards to enable a platform for connectivity that takes the greater good into consideration and enables baseline features that enhance the overall journey and address safety, congestion, emissions etc…

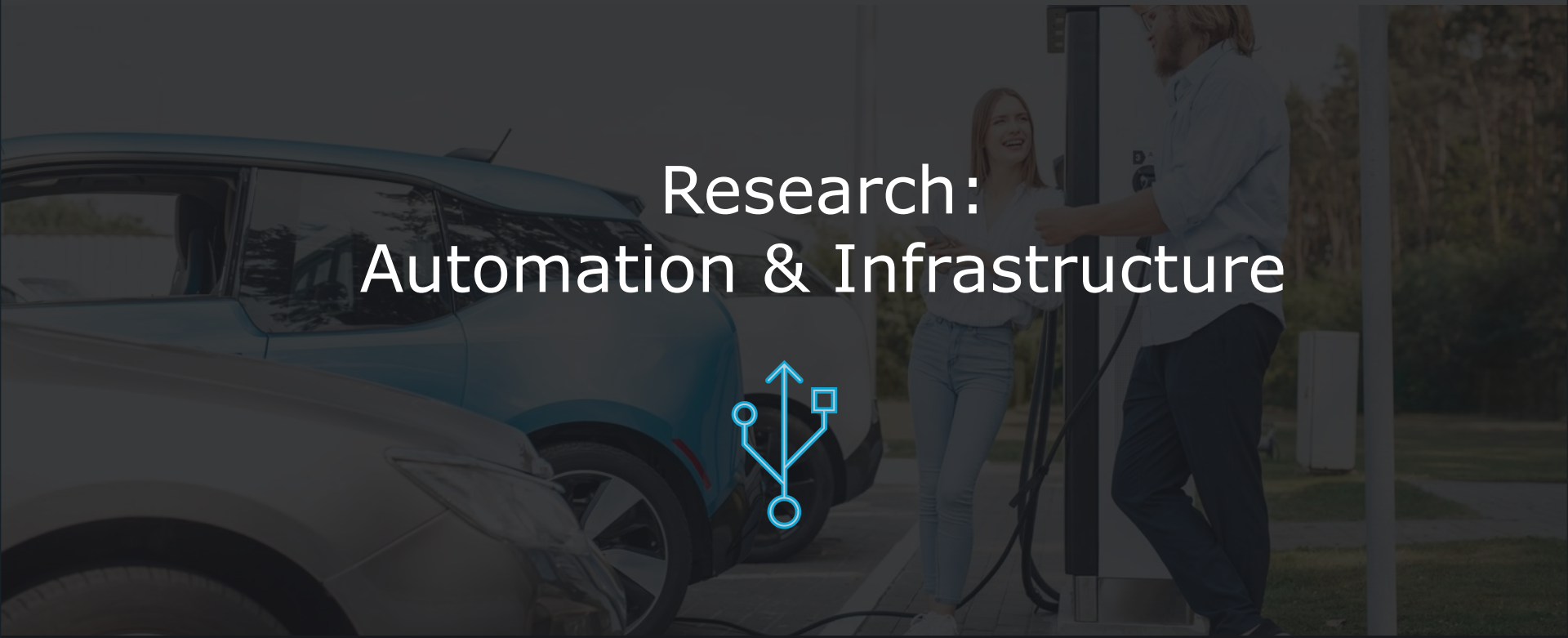
COMPETITIVE DIFFERENTIATION

NEW USER EXPERIENCES

MONETIZATION AND REVENUE SHARING

When the precompetitive/enabling platform is built out for safety and efficiency, competition can flourish in a new connected ecosystem. This new ecosystem allows for new user experiences, differentiation, competition, monetization and revenue sharing to flourish.

Research:
Automation & Infrastructure



Operational Design Domain

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ADS Usage Specification

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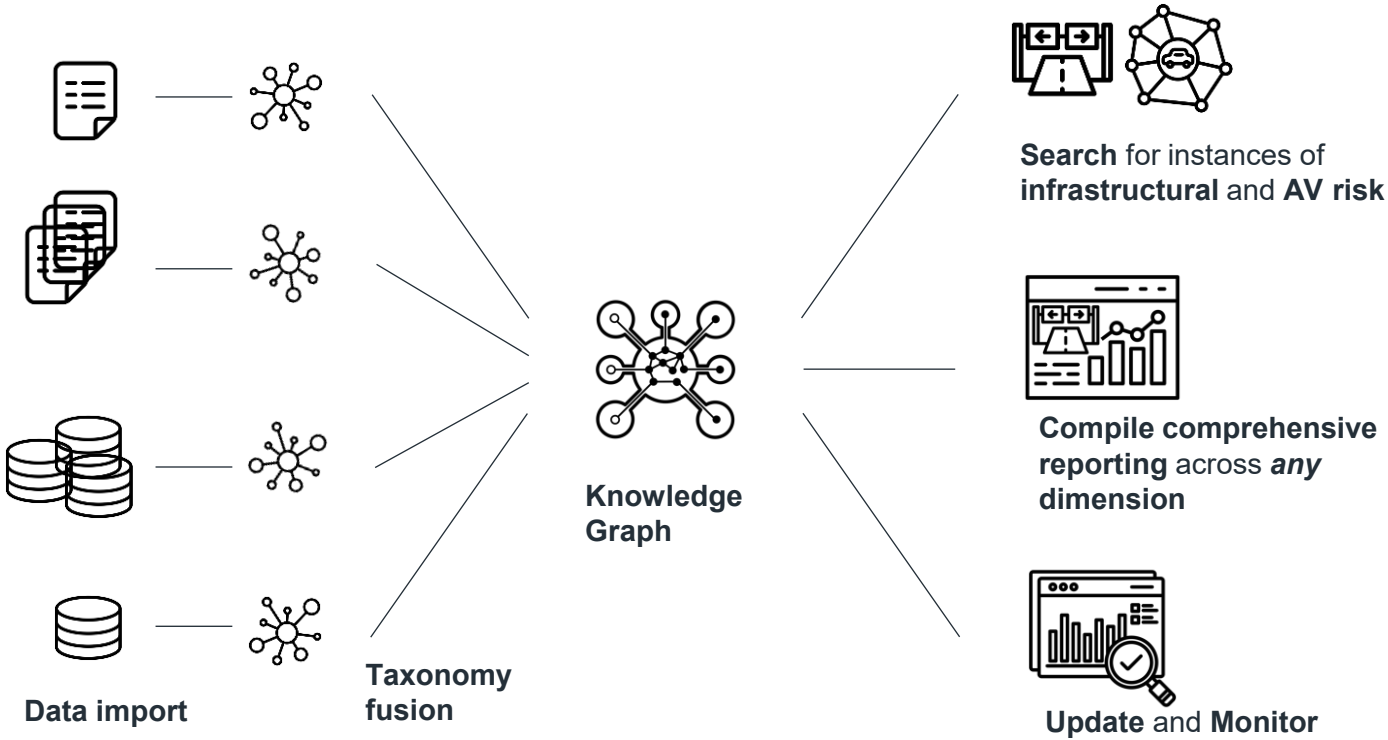
Supports consistency in safety metrics, evaluating safety, creating repeatable tests, assessing infrastructure, and ability to communicate consistently *all require consistent understanding of the context in which an ADS is deployed*.

3.30 USAGE SPECIFICATION

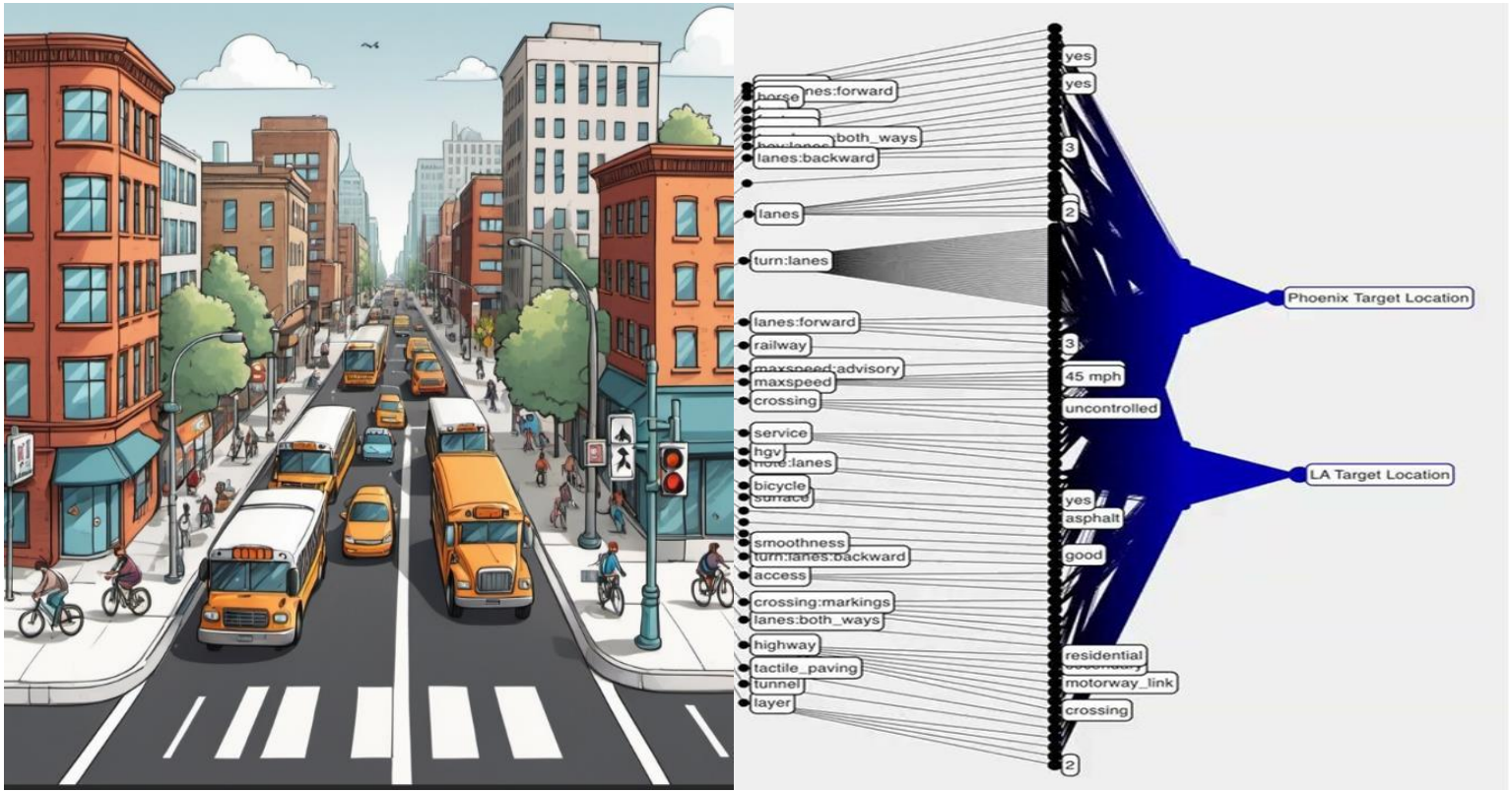
A top-level description of a *driving automation system feature* that includes the level of driving automation, the transportation service intent, and key relevant attributes of the ODD.

NOTE: *Usage Specification* is intended to help multiple stakeholders understand the driving automation system from their perspective. The description of *usage specification* should help stakeholders, including developers, researchers, public agencies, and the general public establish and adjust expectations of system performance.

Scaling Contextual Data



Overview

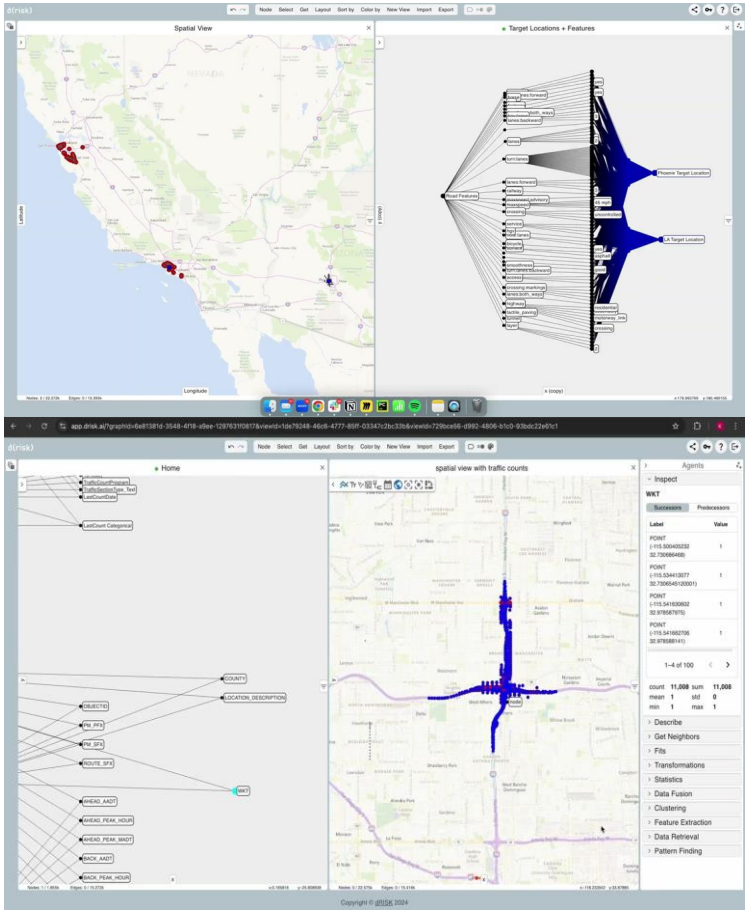


Proof-of-concept

AIM:

Understand **how road infrastructure** characteristics and **ODD definitions** impact the **risk of automated driving**.

Improve consistency and scalability of information for IOOs, developers, third-party test, and regulators



Datasets used:

- *Infrastructure data from two example locations:*
  - *section of freeway in LA*
  - *section of boulevard in Phoenix*
- *AV collisions reported to DMV*
- *Traffic counts*

Using Contextual Data at Scale

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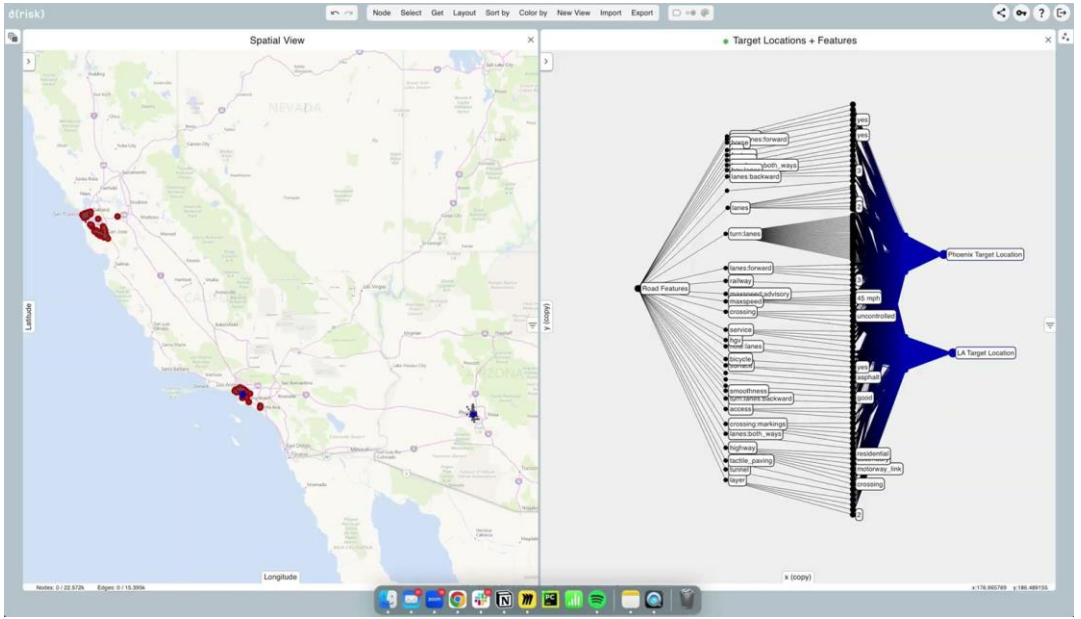
Understand **how or if road infrastructure** characteristics impact **automated driving risk**.

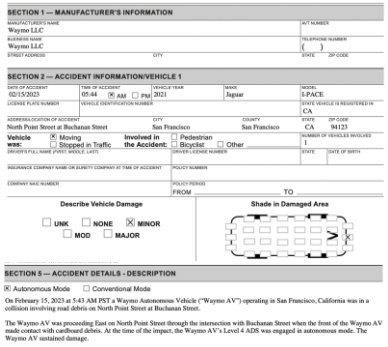
Datasets used

- Infrastructure data from two example locations:
  - section of freeway in LA
  - section of boulevard in Phoenix
- AV collisions reported to DMV



Compiling data

AV crash data



SECTION 1 — MANUFACTURER'S INFORMATION

MANUFACTURER'S NAME: Waymo LLC
AVT NUMBER:
BUSINESS NAME: Waymo LLC
TELEPHONE NUMBER: ( )
STREET ADDRESS:
CITY:
STATE:
ZIP CODE:

SECTION 2 — ACCIDENT INFORMATION/VEHICLE 1

DATE OF ACCIDENT: 02/15/2023
TIME OF ACCIDENT: 05:44 AM PM
VEHICLE YEAR: 2021
MAKE: Jaguar
MODEL: I-PACE
LICENSE PLATE NUMBER:
VEHICLE IDENTIFICATION NUMBER:
STATE VEHICLE IS REGISTERED IN: CA
ADDRESS/LOCATION OF ACCIDENT: North Point Street at Buchanan Street
CITY: San Francisco
COUNTY: San Francisco
STATE: CA
ZIP CODE: 94123
Vehicle was: Moving / Stopped in Traffic
Involved in the Accident: Pedestrian / Bicyclist / Other
NUMBER OF VEHICLES INVOLVED: 1
DRIVER'S FULL NAME (FIRST, MIDDLE, LAST):
DRIVER LICENSE NUMBER:
STATE:
DATE OF BIRTH:
INSURANCE COMPANY NAME OR SURETY COMPANY AT TIME OF ACCIDENT:
POLICY NUMBER:
COMPANY NAIC NUMBER:
POLICY PERIOD: FROM TO

Describe Vehicle Damage: UNK / NONE / MINOR / MOD / MAJOR

Shade in Damaged Area

SECTION 5 — ACCIDENT DETAILS - DESCRIPTION

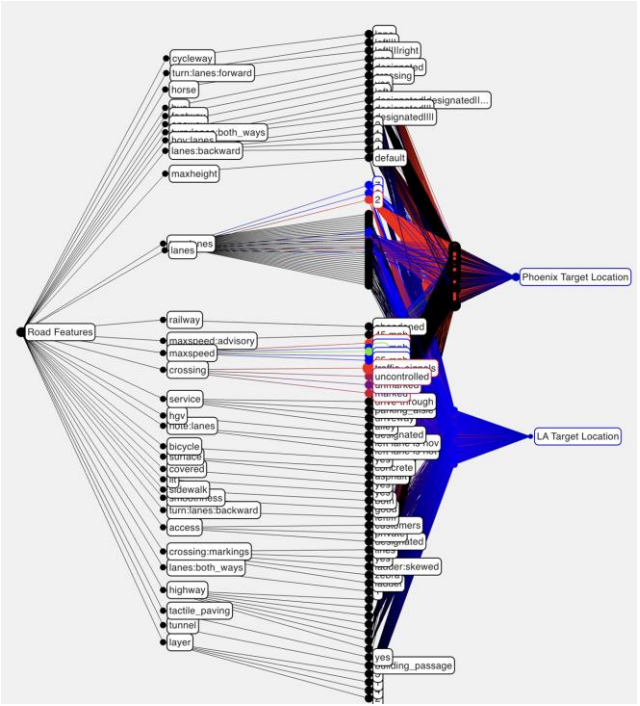
Autonomous Mode / Conventional Mode

On February 15, 2023 at 5:43 AM PST a Waymo Autonomous Vehicle ("Waymo AV") operating in San Francisco, California was in a collision involving road debris on North Point Street at Buchanan Street.

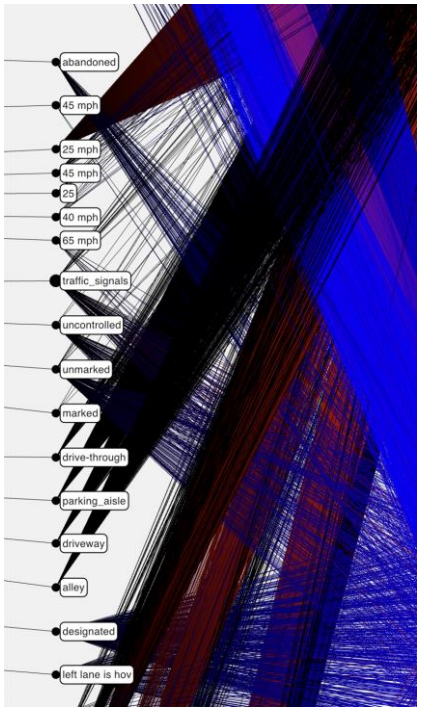
The Waymo AV was proceeding East on North Point Street through the intersection with Buchanan Street when the front of the Waymo AV made contact with cardboard debris. At the time of the impact, the Waymo AV's Level 4 ADS was engaged in autonomous mode. The Waymo AV sustained damage.

OpenStreetMap data

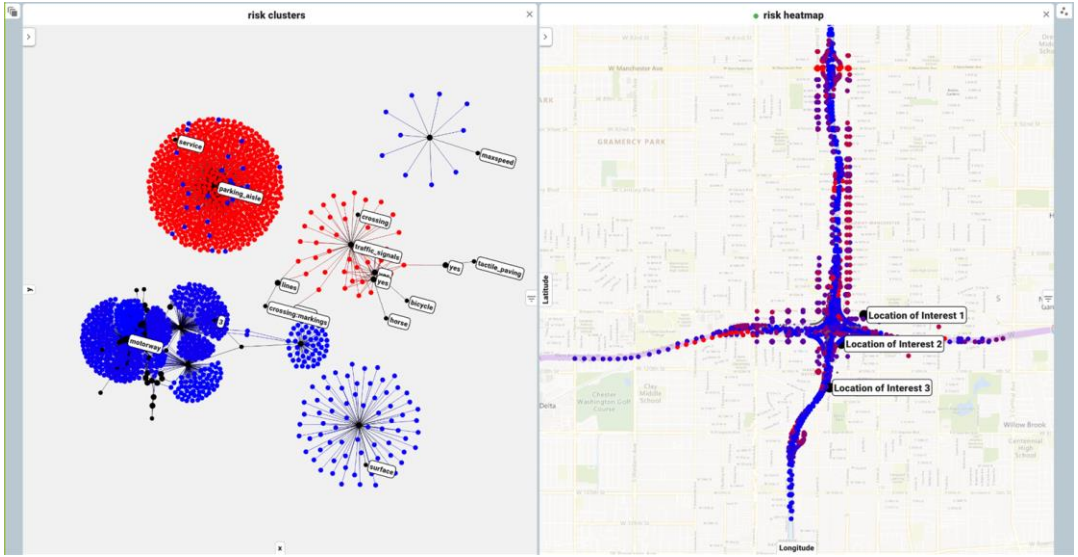
Fused infrastructure



e.g. ***speed features*** *in the taxonomy*



Major Risks Projected onto Los Angeles

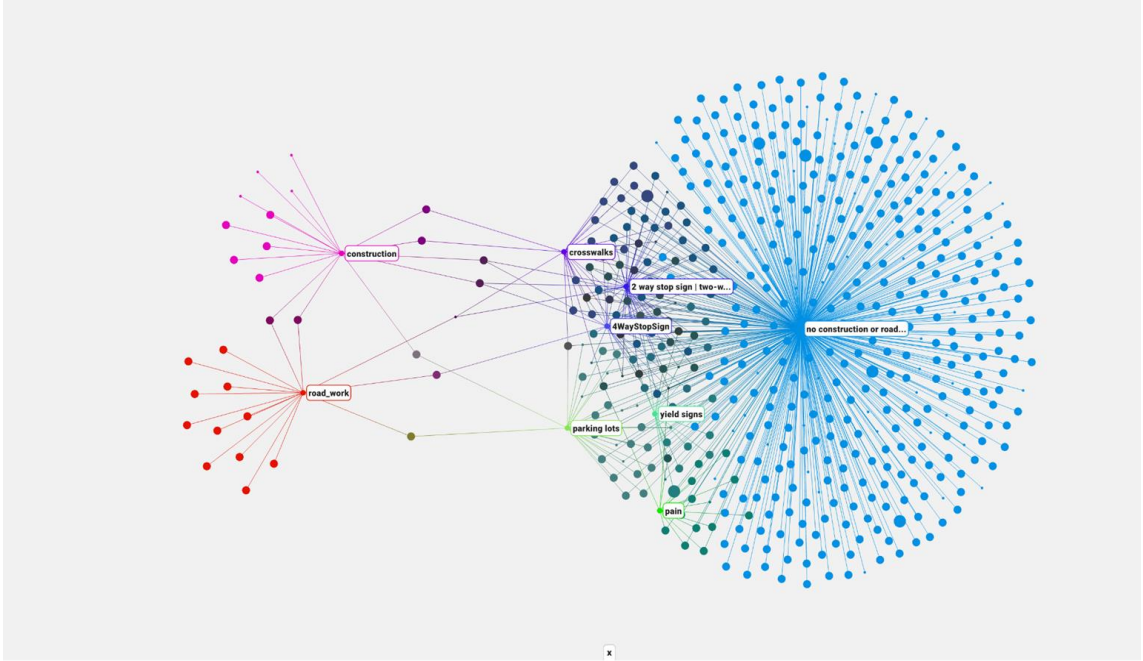


Highest risk locations occur where there are **parking aisles** and **traffic signals.**

There's **lower risk** on **continuous motorways.**

Higher risk on **exit** and **entry ramps.**

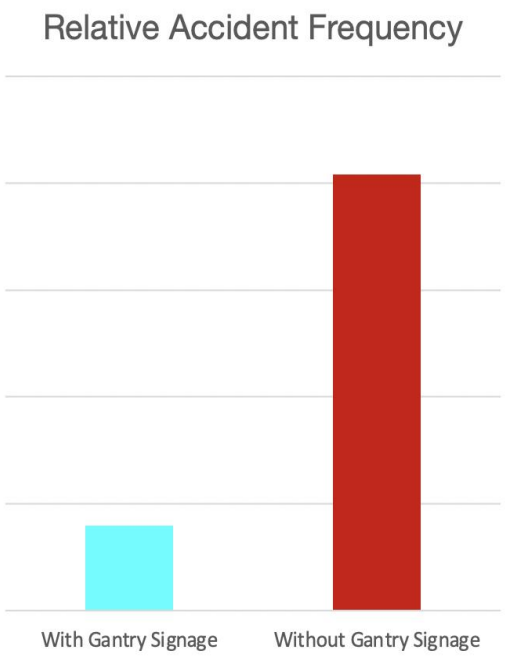
Phenomenology of Infrastructure Risk

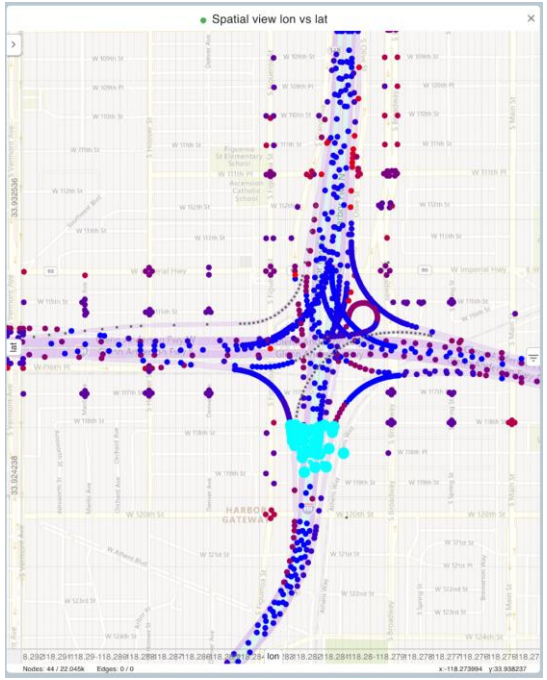


Roadway interventions (road furniture, **new signage** and other infrastructure, and in this case **road works and construction**) can **presage delta to risk**

In this case, full-text featurized data on AV crashes in the graph demonstrates that **road works and construction** are largely a **separable category** from all other **underlying features**

AV Risk Slightly Lower in Existing Gantry Locations

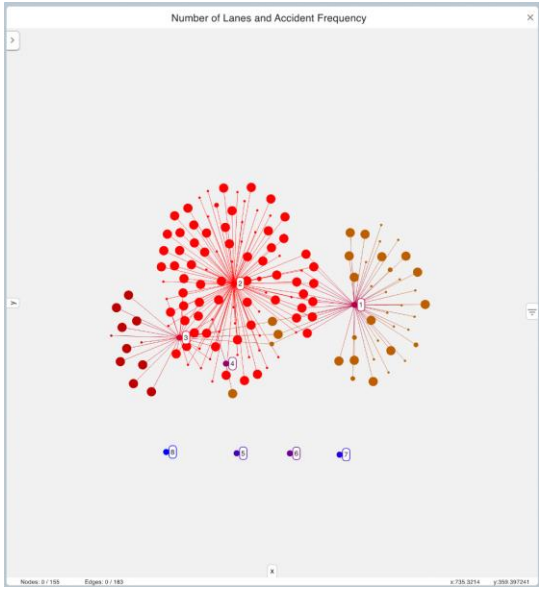


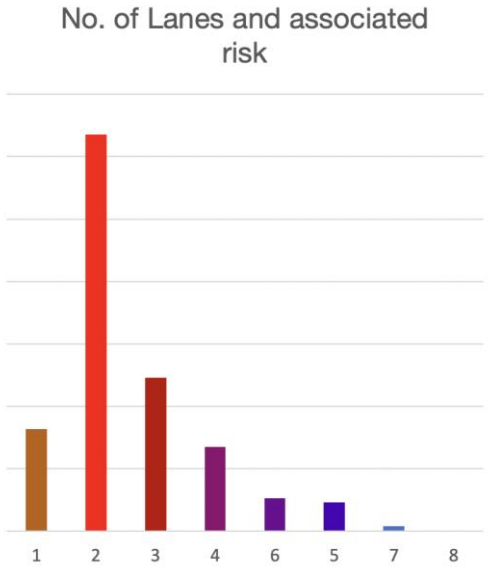


Roadway interventions like **gantry cranes** can **presage delta to risk**

Here is a section of the freeway with gantry cranes with the rest of it without a gantry crane. Data parsed from AV accident locations with gantry cranes vs locations without them correlate to a **safety benefit of having them installed**

AV Risk Higher on Two-lane roads



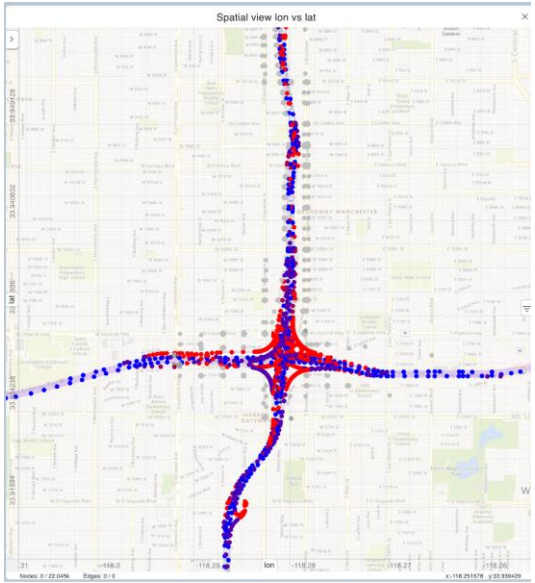


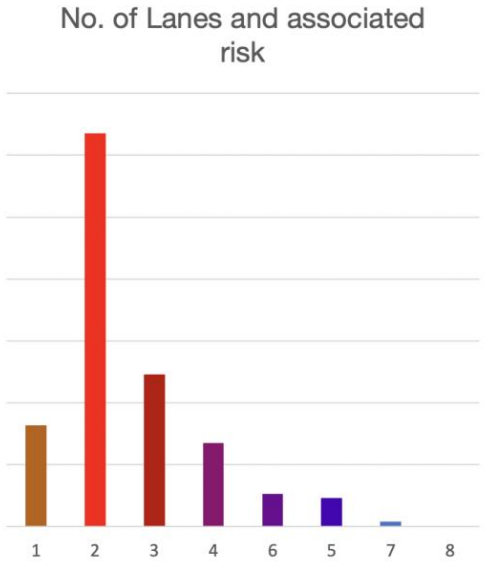
Low probability of **Accidents** along **multi lane freeways** when compared to 2 x 2 forward lane roads.

No AV accidents have taken place on freeways with **5 or more lanes** - speaks to current L4 AV deployment areas.

Follow on work can incorporate tesla and other L2/3 accidents.

AV Risk Higher on Two-lane roads

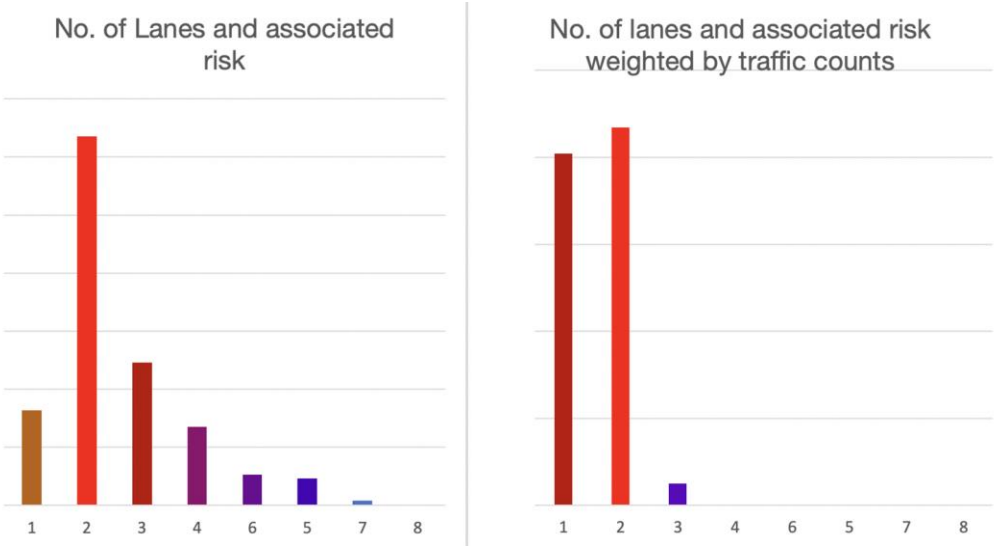




Here the target location is **colored by risk** from number of lanes, routes that involve continuous sections of freeway are less risky.

Exit and **on ramps** are **risky.**

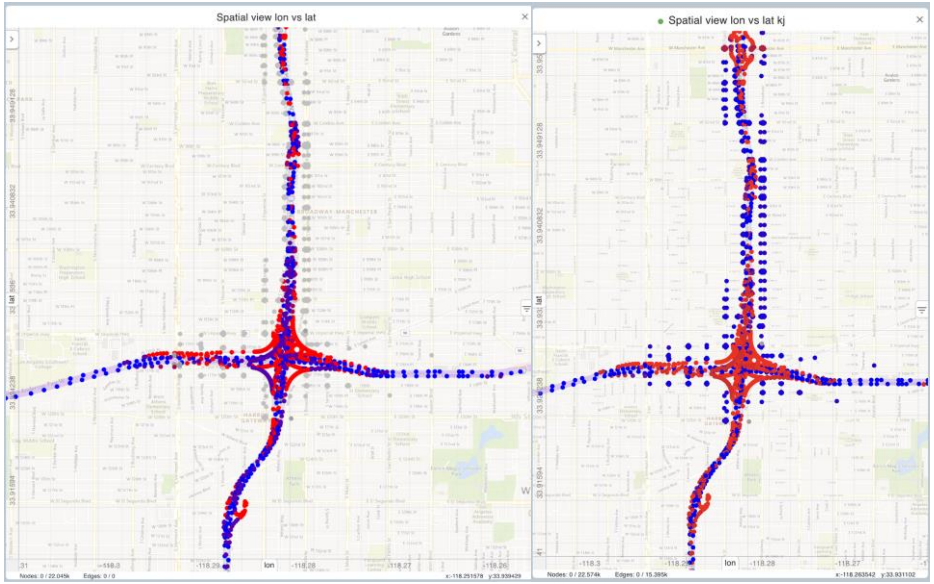
One- and Two-lane roads have even greater risk when weighted with traffic counts



When compared taking into account traffic counts, **2 and 1 lane roads almost equally risky**.

3 or more lane roads and more are far less risky.

One- and Two-lane roads have even greater risk when weighted with traffic counts



When compared taking into account traffic counts, **2 and 1 lane roads almost equally risky.**

3 or more lane roads and more are far less risky.

Exits and on ramps are considerably riskier when considering traffic counts

Methods Overview & Conclusions

5 data sources were fused together, (Map data + AV accident data, local non AV accident data in 2 locations, traffic count) to determine risk of a new target location based on physical infrastructure.

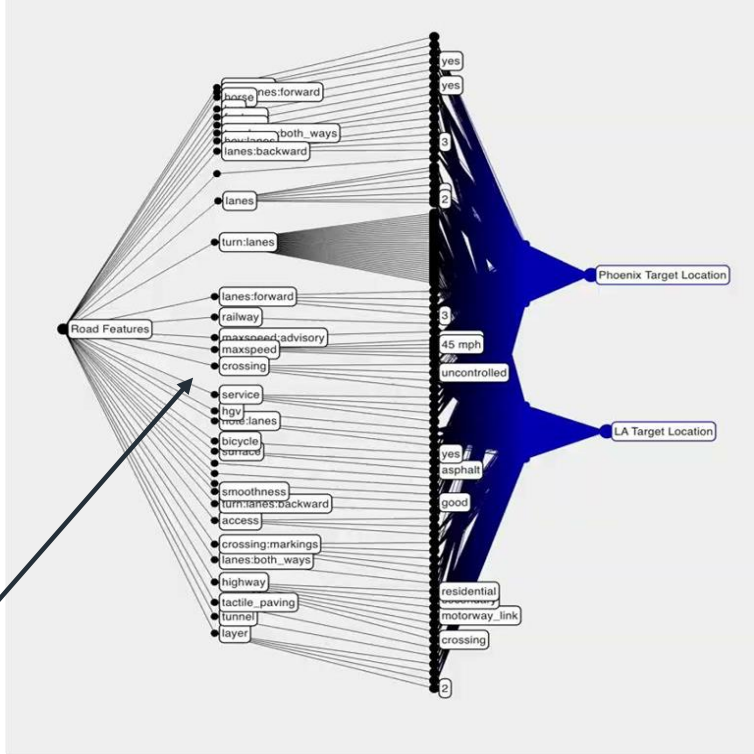
Highway section in **LA**

Boulevard section in **Phoenix**

Greater risk associated with: Median speed limit locations, **2 lane boulevards + 1 lane roads**, **street parking aisles + traffic signals**

More research is needed regarding causal relationships but Infrastructure considerations can inform AV deployment risk and likewise, inform infrastructure investment.

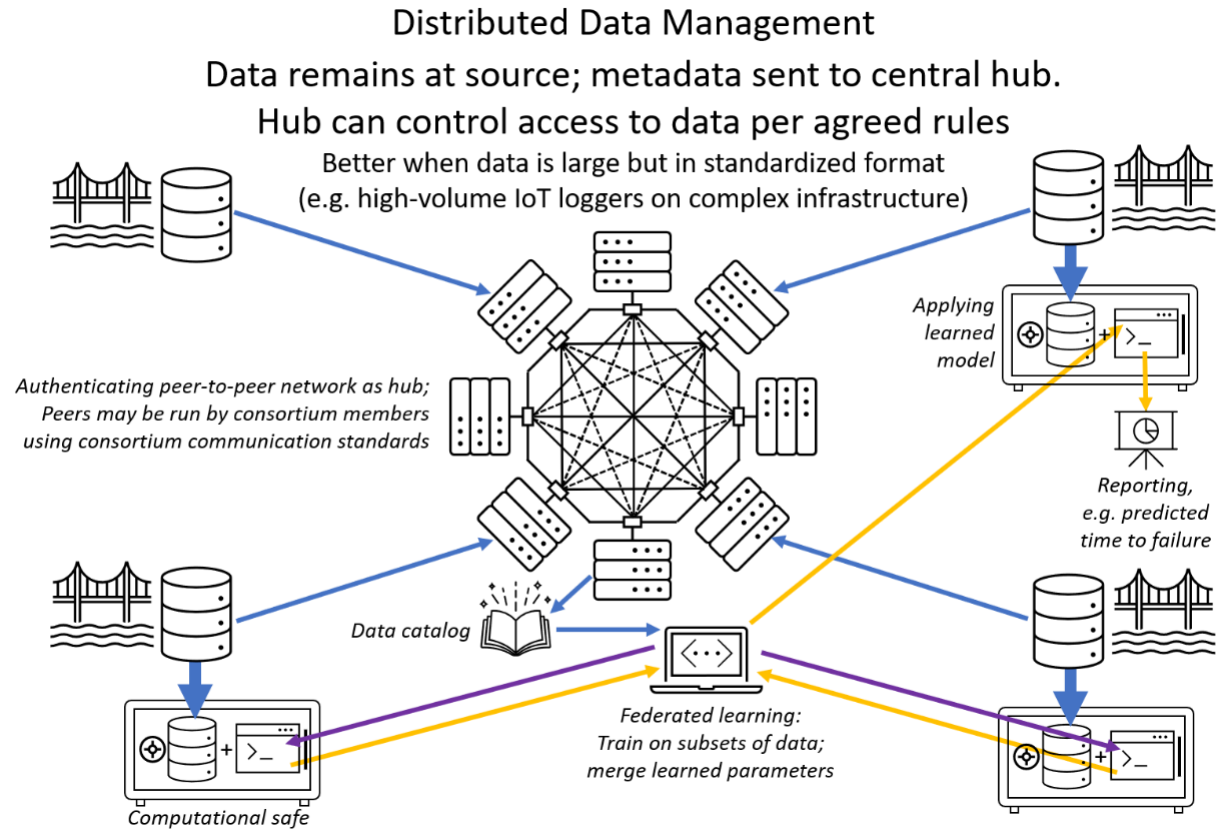
1. Standardizing infrastructure labels can accelerate data collection and improve consistency of interpretations.
2. Creating mechanisms to collect, share, monetize data can accelerate scale.



North American Digital Data Standard

- The goal of this project is to develop a standard(s) that describes Connected and Automated Vehicles (CAV) object data, encompassing both vehicle and infrastructure aspects.
- Supports CAV performance, improve individual and comparative evaluation and validation, and traffic management operations by simplifying data aggregation and analyses.

Data exchange concepts: distributed data management

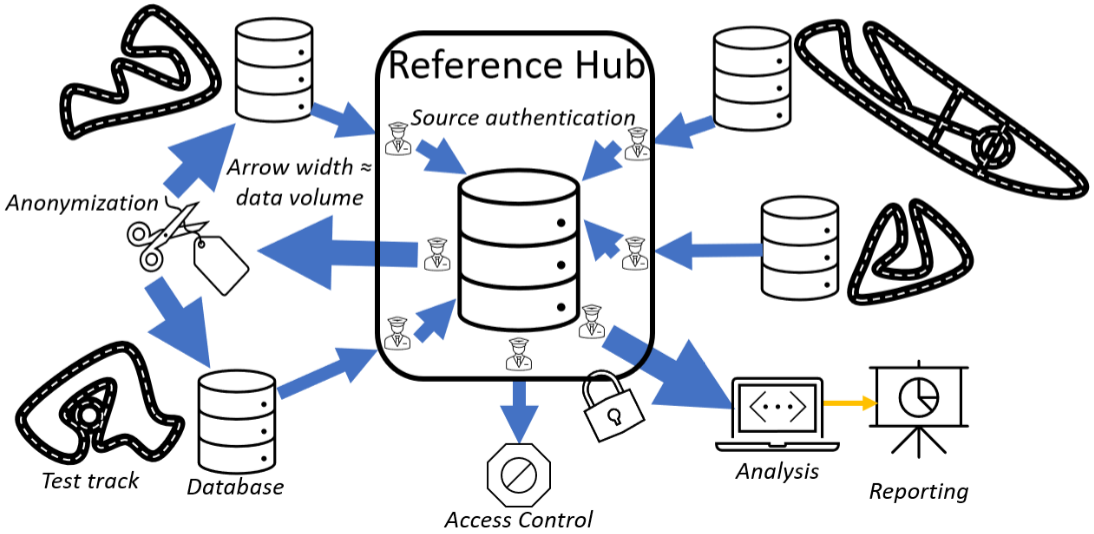


Data exchange concepts: central data management

Central Data Management

Data is copied from various sources to a central server, which can do joint analysis, control access, & return analyzed or anonymized aggregated data to contributors. The central server must remain online but the sources do not.

Better when data is small & can beneficially be treated as a larger set
(e.g. AV test cases being collected from different test tracks)



Workforce

ATTC
Autonomous Truck Technician Consortium
A Program of SAE ITC

- Launch, recovery, and enroute services require technicians with skills unique to autonomous trucking.
- Pre- and post-launch inspection best practices needed to launch and land autonomous trucks.
- To ensure successful missions, best practices will:
  - Avoid individual technicians being employed by each manufacturer;
  - Allow for the sharing of technician resources within shared depots;
  - Ensure standard interactions, servicing, and the maintenance of sensors & onboard automated driving systems.

Workforce: battery technicians

"With the world transitioning to a more sustainable future, our program provides critical knowledge and skills to stay ahead of the curve and seize emerging opportunities. Unlike other training programs, we offer a unique, cross-sector structure that covers all aspects of advanced battery and energy system technologies. Our goal is to equip our learners with a full understanding of these technologies so that they can succeed in the global transition to clean transportation."

SAE INTERNATIONAL | eit InnoEnergy Skills Institute

BATTERY ACADEMY

22 On-Demand Courses
World-Renown Experts

200 + Hours of Learning

- Battery Fundamentals
- EV Batteries
- Battery Management Systems
- Cybersecurity
- Grid & Utility Energy Storage

Department of Energy

DOE and DOL Announce New Effort to Support and Expand America's Battery Workforce

MARCH 26, 2024

Battery Workforce Initative

LANSING, MI— The U.S. Department of Energy (DOE), in coordination with the U.S. Department of Labor (DOL), today announced the release of the Battery Workforce Initiative (BWI)'s National Guideline Standards for registered apprenticeships for battery machine operators. The DOL-certified guidelines, created in partnership with battery manufacturers, community colleges, and unions, lay out rigorous training requirements to support the skilled workforce needed in this rapidly growing industry as electric vehicle (EV) sales have quadrupled and nearly 300 new or expanded battery facilities have been announced since President Biden took office. Energy Secretary Jennifer M. Granholm and Acting Labor Secretary Julie Su, joined Michigan Governor Gretchen Whitmer and U.S. Representative Elissa Slotkin and UAW President Shawn Fain in Lansing, MI to announce BWI's new Standards alongside industry, workers, educators, and students at UAW Local 652Union Hall, near the Ultium factory being constructed with **support** from DOE's Loan Program Office.

Upskilling & Reskilling: engineering, operations, sales & marketing, and more

Custom learning plans

Leverages SAE & InnoEnergy Skills Institute's Battery Academy.

Over **220 hours of accredited content to develop critical skills** in battery design, manufacturing, testing, safety, regulations, market opportunities and more…

Ability to develop **custom learning programs based on individual or team needs**, complement existing learning & development solutions with à la carte offerings and multiple modalities: in-person, hybrid, e-learning or on-demand courses

Technical learning pathways

For Engineers, R&D, and other technical professionals

Electrical Engineers: Battery Management Systems, Power Converters and Efficiency in Battery Applications, Battery Management Connection and Control

Chemical Engineers: Materials to Electrodes, Electrodes to Cells, Solid-State Batteries, Battery Supply Chain, Battery Safety

Mechanical Engineers: Battery Management Systems, Battery Management Connection and Control, Battery Testing,

Power Electronics Engineers: Power Converters and Efficiency in Battery Applications, Battery Management Connection and Control, Battery Storage Applications

Non-technical learning pathways

For sales, marketing, supply chain, project management, regulatory, and more

Supply Chain Manager: Battery Supply Chain, Battery Storage: Business Models, Market, and Regulation, Materials to Electrodes, Battery Supply Chain

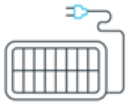
BDM: Battery Storage: Business Models, Market, and Regulation, Battery Storage Applications, Battery Storage and the Energy Transition

Regulatory Affairs: Battery Storage: Business Models, Market, and Regulation, Battery Management Systems, Battery Safety, Managing Energy Data

EHS Manager: Battery Safety, Battery Management Systems, Battery Testing, Understanding Energy Storage, The Battery Revolution

Battery Training Courses – Automotive

Introduction to Battery Technology in BEVs, HEVs, and PHEVs



This course explores the design and performance of battery technologies used in today's battery-electric vehicles, and focuses on the skills required to define a battery pack design, how battery packs are manufactured, and tests required before entering the market.

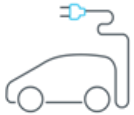
- Summarize the fundamental electrochemistry of battery operation and performance requirements.
- Explain the functions of components within thermal cooling systems, including their impact on battery
- Describe the function of the Battery Management System
- Indicate components of the structural design of a battery pack

Fundamentals of High Voltage xEV, Safety, and PPE

This one-day course explains EV safety fundamentals, including personal protective equipment (PPE) and how to develop and establish common safety procedures for working around high voltage vehicles.

- Describe the various xEVs subsystems and components
- Identify, select, test, care for high voltage (HV) electrical gloves per ASTM requirements
- Recite the steps to disable a HV EV
- Determine how to deal with HV vehicle subsystems during vehicle crash
- Examine the EV HV system for faults, failures, and discharge circuits

Hybrid and Electric Vehicle Engineering Academy



This course covers hybrid and electric vehicle engineering concepts, theory, and applications relevant to HEV, PHEV, EREV, and BEV for the passenger car industry.

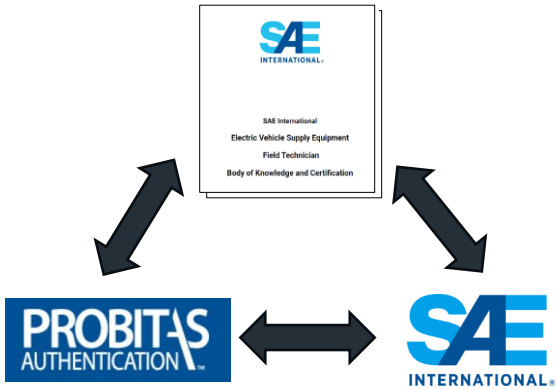
- Estimate the size of a cell to meet a specific requirement
- Compare and contrast the various industry and regulatory standards for hybrid vehicle components, batteries, and charging systems
- Describe the main hybrid and electric vehicle development considerations and performance requirements for various vehicle system

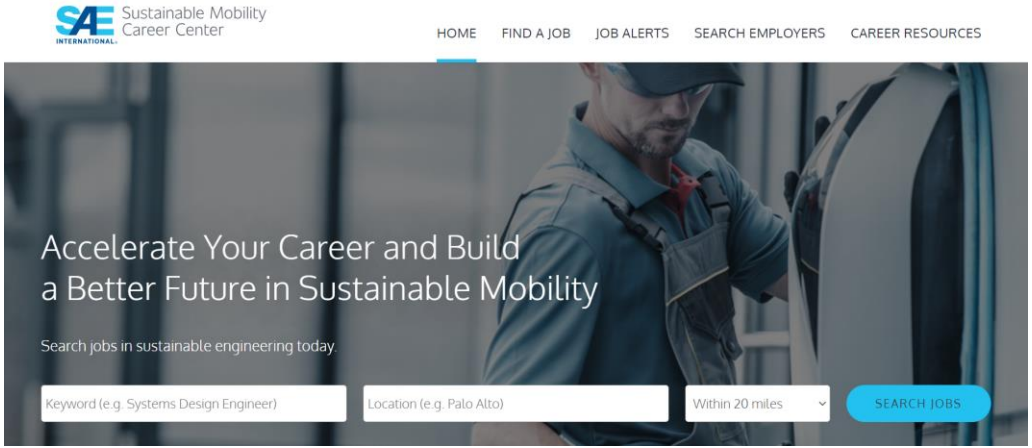
Supporting federal initiatives

Li-Bridge is a public-private alliance aimed at bridging the lithium battery supply chain gap. It works to bring together stakeholders **to develop and execute a national strategy to build a robust battery supply chain**.

Argonne, working with its sister Department of Energy (DOE) labs, has partnered with three U.S.- based convenor organizations that bring private industry to the table. To date, these organizations are: NAATBatt International, New York Battery and Energy Storage Technology Consortium (NY-BEST), and SAE International.

Workforce: EVSE technician

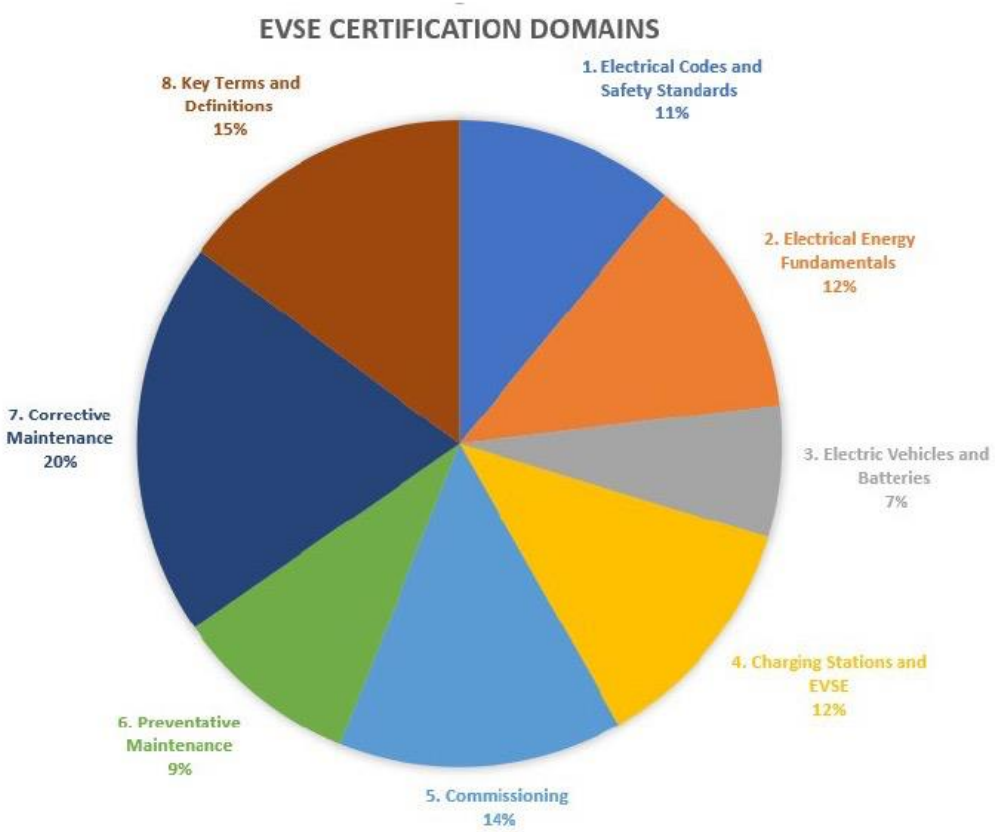




advisory panel

flo EV Charging · TESLA · chargepoint · CH! · ABB · RIVIAN

Workforce: EVSE technician domains



EVSE technician Certification Deployment

- Over 4,500 testing centers
- Every major metropolitan city in the U.S.A.
- Access, Equity & Inclusion
- Empowering clean tech jobs of tomorrow

While traceability is key to sustainability and global competitiveness

What Is the Battery Passport?

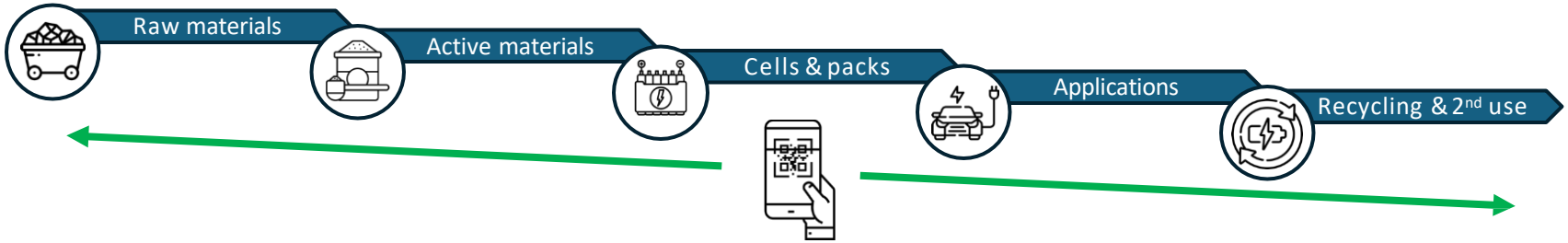
- **Global Traceability Standards**: Establish common data and security protocols for batteries across the supply chain.
- **Mineral Provenance Traceability**: Ensuring responsible sourcing of critical battery minerals.
- **Lifecycle and Sustainability**: Providing standardized data for safety, performance, and recycling.

Why Industry Leaders Need to Be Involved

- **Shape Global Standards**: Ensure the standards reflect industry needs, making compliance both effective and achievable.
- **Lead Innovation**: Drive practical, scalable solutions for traceability, safety, and sustainability.
- **Global Competitiveness**: Position U.S. battery manufacturing as a leader in sustainability & transparency and gaining a competitive edge in the global market.

Focus Areas in the SAE J3327 Standard

- **Mineral Provenance**: Standards for tracing origins to ensure ethical sourcing and due diligence.
- **Battery Performance and Lifecycle**: Common data formats for optimizing performance, enhancing safety, and supporting recycling.
- **Sustainability and Interoperability**: ESG reporting to enable a sustainable, internationally consistent value chain.



Ensuring safety throughout value chain drives adoption of battery technology

Why safety standards?

- **Safe Deployment**: Establishes a minimum set of safety criteria for lithium-based batteries, critical for safe vehicle integration.
- **Risk Mitigation**: Helps identify and manage failure modes, ensuring safe operation under all conditions, within and outside of spec.
- **Unified Benchmark**: Provides a common set of safety expectations across manufacturers, improving consistency and reliability in safety assessments.

SAE J2929 Standard Scope

- **Vehicle Propulsion Safety**: Establishes criteria for lithium-based battery systems used in high voltage vehicle propulsion applications.
- **Comprehensive Testing**: Focuses on safety evaluations at the cell, module, and pack levels, including thermal management and physical support systems.
- **Baseline, Not a Limit**: Designed as a minimum standard—additional requirements can be added by manufacturers to meet specific application needs.

Driving Industry-Wide Adoption and Best Practices

- **Unified Safety Across the Industry**: Ensure consistent practices across manufacturers.
- **Cost-Efficient Compliance**: Implementing a ready-to-go set of safety standards to meet regulatory requirements more efficiently
- **Global Alignment**: SAE safety standards facilitate easier access to international markets by aligning U.S. battery safety practices with emerging global benchmarks.

Be Part of Establishing Best Practices: Collaborate to ensure these standards reflect operational realities, enabling practical and scalable adoption of safety measures across the battery value chain.

Battery manufacturing roadmap

2024

99 battery and EV standards identified and in development.

2026

Key safety and interoperability standards.

2028

Suppliers scale by adopting common standards, driving costs down.

2030

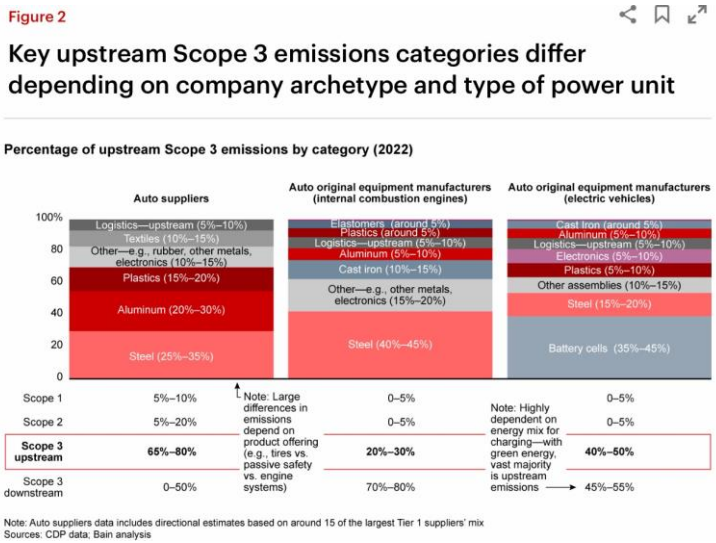
US battery market scales to 1,000 GWh/year

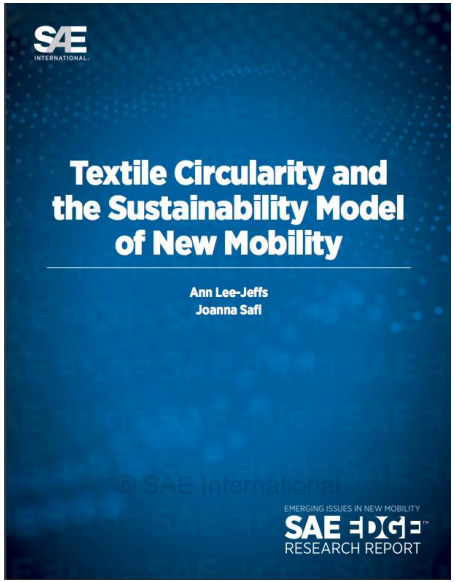
Materials & Advanced Manufacturing

Circular economy

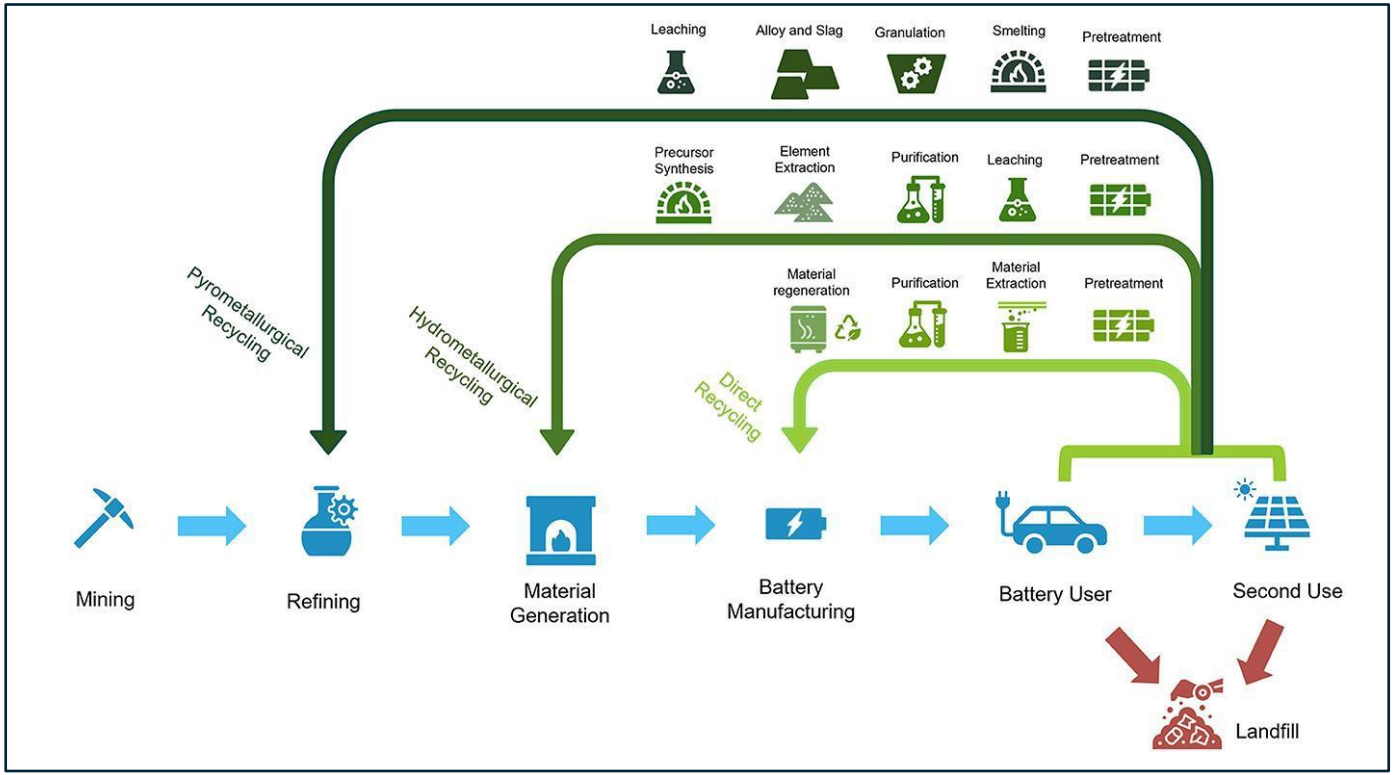
Evolving new ways to map environmental impact

- **Metals.** The EU's digital product passport system includes metals as part of its construction materials product group. At the same time metals (including battery metals) account for the largest portion of Scope 3 emissions in vehicle manufacturing. SMS is working on a framework/best practice in environmental data declaration for metals and this area also seems to require data and process assurance to be successful.





Circular economy



SCORE

SUPPLY CHAINS OF RECOVERED ELEMENTS

- Defense industrial base highly dependent on foreign minerals for which the US has no substitutes and no supply alternatives
- SCORE exists to build manufacturing supply chains for domestic sourcing, production, and use of critical minerals

https://www.scoreconsortium.org/

AMCC™

ADVANCED MANUFACTURING COMMERCIALIZATION CENTER

An SAE Government Technologies™ Program

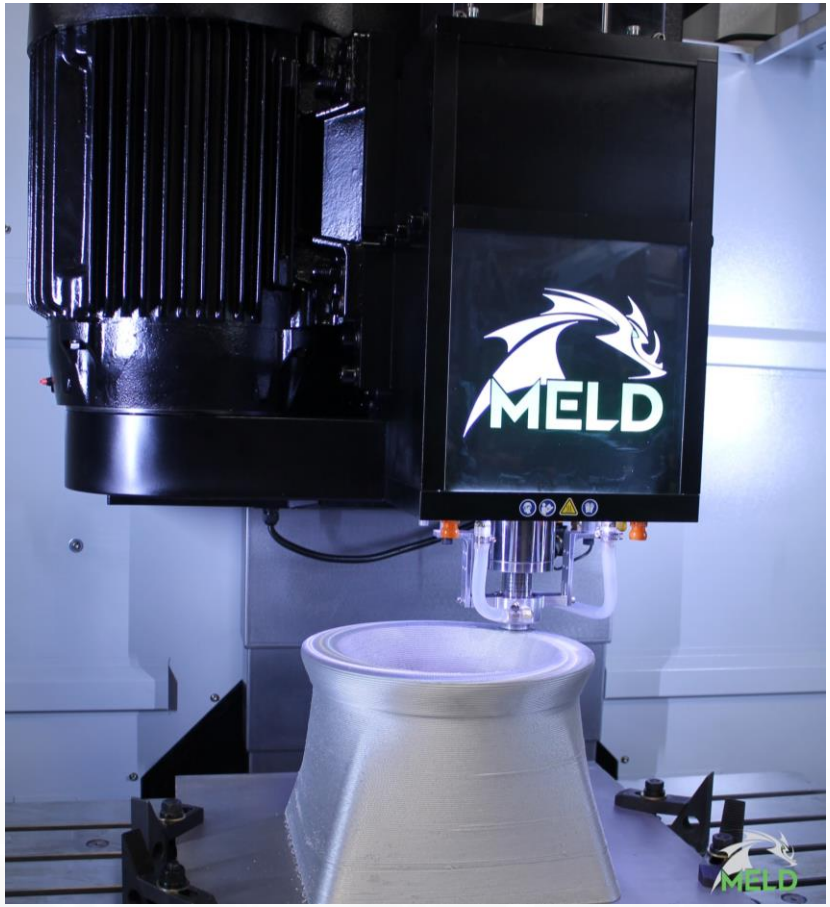
The AMCC is a cutting-edge manufacturing center supporting modernization and sustainment in defense and commercial applications.

The center develops and commercializes advanced manufacturing processes and standards that accelerate product development, reduce costs, and keep legacy vehicles and aircraft moving.

Developed in partnership with the U.S. Army Ground Vehicle Systems Center.

Relevant, Primary NAICS
541330

DEVCOM GROUND VEHICLE SYSTEMS CENTER



- 6775 Center Drive, Sterling Heights
- 39,000 ft^2 Manufacturing Space
- 5,500 ft^2 Office Space
- State / Local Support
- Will Execute Other Funded US Government / Commercial Work

AMCC™
ADVANCED MANUFACTURING COMMERCIALIZATION CENTER
An SAE Government Technologies™ Program

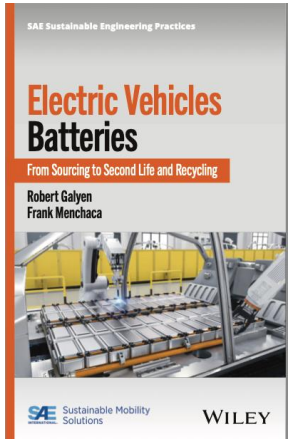
Hybrid / Electric Vehicles

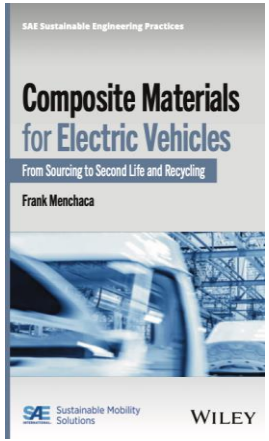
Resiliant Infrastructure

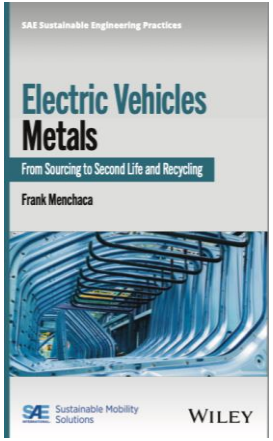
Mobility, Advanced™

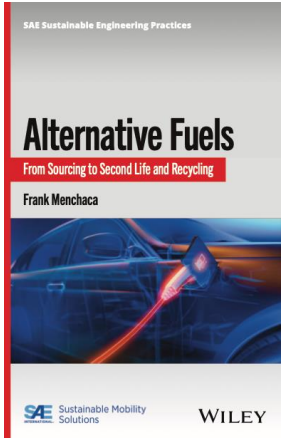
Through a series of course books SAE is defining a knowledge system for resilient mobility infrastructure.

Sustainability, automation, artificial intelligence and changes to the supply chain: these and other factors are transforming transportation infrastructure in terms of *how it is built, how it functions and who works in it*.





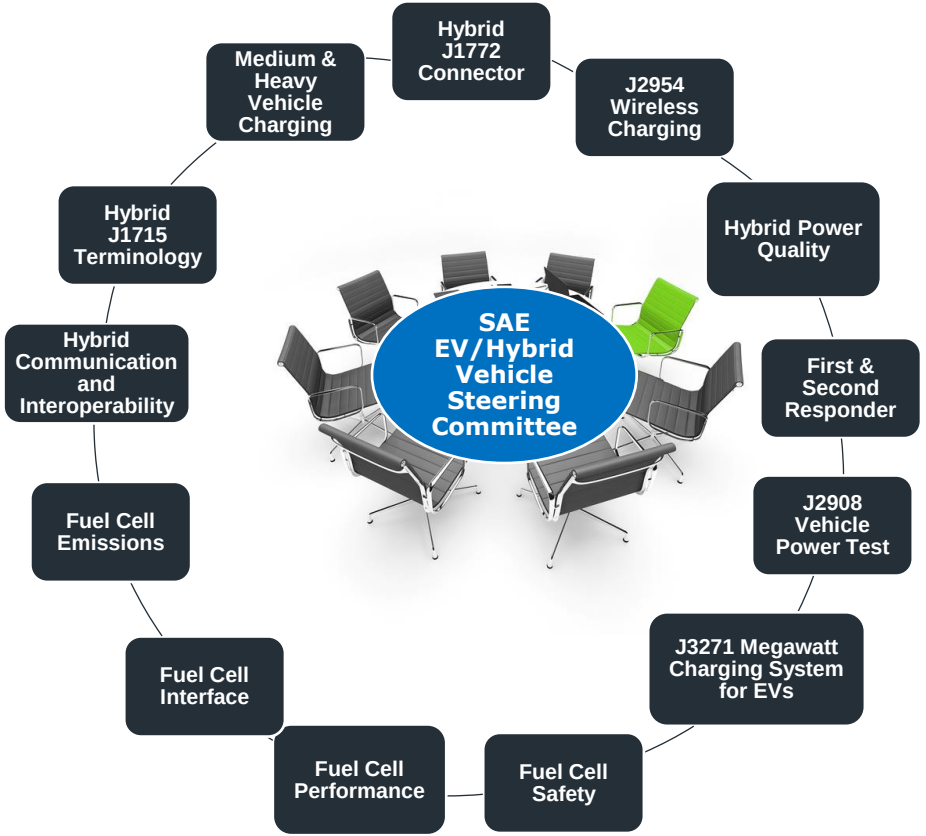




SAE EV, Hybrid & Fuel Cell Vehicle Standards Development

SAE EV / Hybrid Vehicle Steering Committee

- Started – 2005
- Current Committee Membership
  - > 1100 Individual Participants
  - > 500 Companies
    - OEM's
    - Suppliers
    - Government
    - Academia
- 10 EV / Hybrid Vehicle Subcommittees
- 4 Fuel Cell Standards Subcommittees
- 66 SAE EV, Hybrid, Fuel Cell Vehicle Standards Published to Date



SAE Battery Standards Committee Documents

Thermal Management & Adhesives: J3073, J3178, J3301

Battery Labeling: J2936

Battery Testing Methodologies: J2758, J2380, J3220,J2289, J2288

Battery Materials Testing: J2983, J3021, J3042, J3159, J3277/1, J3277, J1798/2, J1798/1

Battery Transport: J2950, J3235

Battery Recycling: J3071, J2974, J2984

Starter & Storage Batteries: J1495, J2185, J240, J2801, J2981, J3060, J537, J930, J2981

* WIP

Battery Life Assessment Testing: J240, J2185, J2288, J2801

Electric Drive Battery Systems Functional Guidelines: J2289, J3296

Battery Vibration: J2380, J3060

Battery Secondary Use: J2997

Capacitive Energy & Start/Stop: J3012, J3051

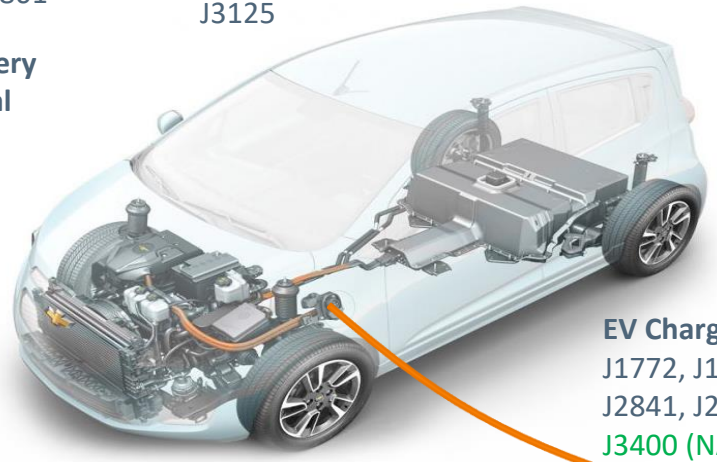
Battery Terminology: J1715/2

Battery Size, Identification & Packaging: J1797, J3124, J2981, J3004

Truck & Bus Batteries: J3004, J3125

Battery Safety: J2929, J2464, J3009

SAE Hybrid-EV Committee



EV / Battery Fuel Economy & Range: J1634, J1711, J2711, J2758

EV Charging: J1772, J1773, J2293, J2836, J2841, J2847, J2894, J2931, J3400 (NACS)

EV Battery Safety: J1766, J2344, J2910, J2990

EV Charging Safety: J1718, J2953/1, J2953/2, J2953/3

Battery Performance & Power Rating: J1798, J2758

Battery Electronic Fuel Gauging & Range: J2946, J2991

SAE EV, Hybrid, Fuel Cell Vehicle Std's on Vehicle Safety

J2990 & J2990/1:

- Emergency Response Guides (Immobilize, Disable, Warnings)
- Vehicle Type Identification (Badging)
- High Voltage Shutdown (Disconnects, Battery & Converter Cables
- Tow & Inspection Guides (Recovery, Isolation, Inspection, Diagnostics)
- Hazard Communication

- **J2990** - Hybrid and EV First and Second Responder Recommended Practice
- **J2990/1** - Gaseous Hydrogen and Fuel Cell Vehicle First and Second Responder Recommended Practice
- **J3108** - EV Labels to Assist First and Second Responders, and Others (high voltage safety info.)
- **J2344** - Guidelines for Electric Vehicle Safety (EV, HEV, PHEV and FCV high voltage systems)
- **J2578** - Recommended Practice for General Fuel Cell Vehicle Safety (fuel cell system, storage & high voltage)
- **J1766** - Recommended Practice for Electric, Fuel Cell and Hybrid Electric Vehicle Crash Integrity Testing
- **J2910** - Recommended Practice for Design & Testing Hybrid Electric/Electric Trucks/Buses for Electrical Safety

SAE J3311: Vehicle Platform Power Management

Mobility, Advanced™

Leveraging lessons learned: desktop -> laptop

- Defines a power management framework based on Advanced Configuration and Power Interface (ACPI) system principles but designed for the vehicle architecture.
- Information applicable to all types of automotive E/E system architectures
- Globally enable efficiencies in product development and validation between OEMs and the supply chain while maximizing reuse of ECUs and devices between OEM vehicle systems.

Committee website

The need is driven by the increasing complexity and reliance on electronic systems in modern vehicles and the ever-larger amounts of energy they consume. This standard will address the challenge by defining at a high level the interfaces, components and power states required to apply vehicle platform power management policies.

https://www.sae.org/news/press-room/2024/01/sae-j3311-committee

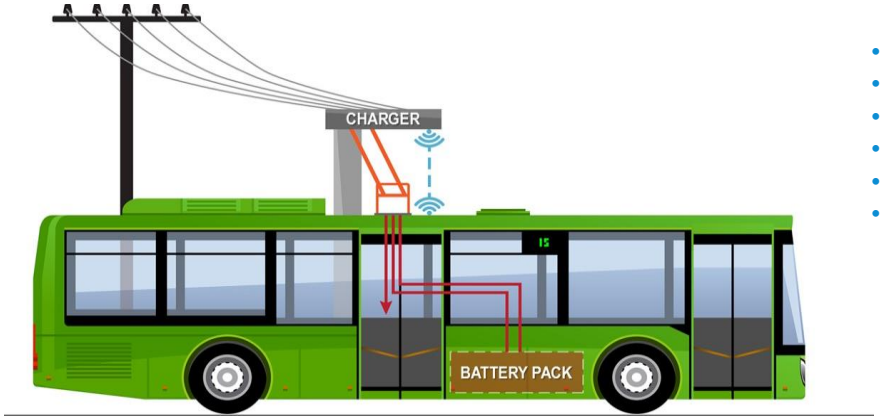
SAE J3400 – NACS Charging

SURFACE VEHICLE RECOMMENDED PRACTICE	J3400™	SEP2024
	Issued 2023-12 Revised 2024-09 Superseding J3400 DEC2023	
(R) North American Charging System (NACS) for Electric Vehicles		

Covers the general physical, electrical, functional, safety, and performance requirements for conductive power transfer to an electric vehicle using a coupler, which can be hand-mated and is capable of transferring either DC or AC single-phase power using two current-carrying contacts.

SAE J3105 Overhead & Portal Charging

- SAE J3105 Automated charging connection at high power
  - Document will standardize the interface between the infrastructure and the bus
  - Targeted towards in-route DC charging
  - DC Power Levels (Voltage Range: 250-1,000 DC Volts) up to 1MW
- SAE J3105/1Electric Vehicle Power Transfer System Using Conductive Automated Connection Devices including Infrastructure-Mounted Pantograph (Cross-Rail) Connection
- SAE J3105/2 Vehicle Mounted Pantograph



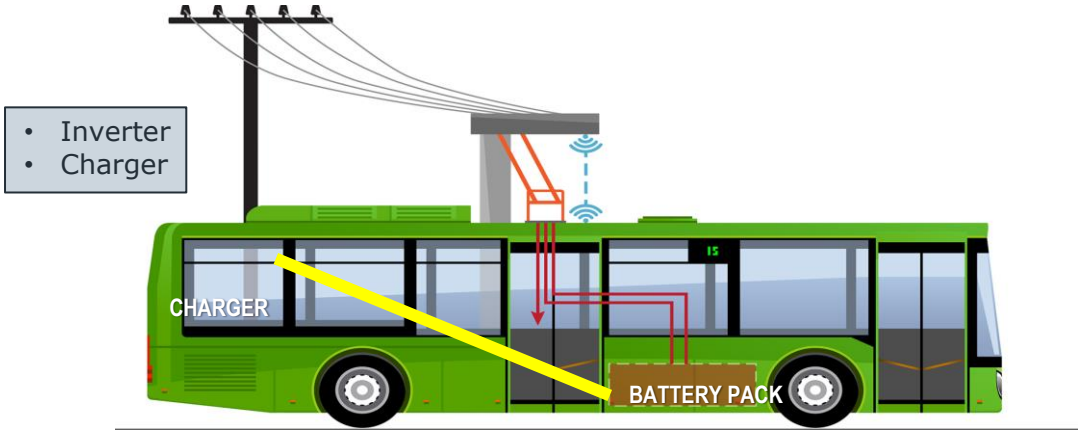
- **DC Power Levels**
- **Power Configurations**
- **Connection Points**
- **Communications**
- **Safety**
- **Alignment Protocol**

SAE J3068 AC Depot Conductive Charging

Depot Charging - 3 Phase AC (J3068) targeted towards charging at commercial and industrial locations or other places where three-phase AC power is available and preferred such as at commercial and industrial locations (160A 480VAC 3ø = 133kW)

Defines a conductive power transfer method including the digital communication system. It also covers the functional and dimensional requirements for the vehicle inlet, supply equipment outlet, and mating housings and contacts

SAE J3068 3 phase AC



SAE J2954 Wireless Power Transfer

for Light-Duty Plug-In/Electric Vehicles

SAE J2954 establishes minimum performance, interoperability and safety criteria for wireless charging of EVs / PHEVs

SAE J2954 Standard Development

- Inductive Charging Interoperability
- Automated Charging
- Power Transfer Communications
- Smart Grid Interoperability
- Automatic Shutdown Capability
- Automated Valet Parking / Charging

SAE J2954 Published
October 2020
Revised August 2022

Charging Locations:

Residential
Public
On-Road
Parking lots
Curb side

Key aspects:

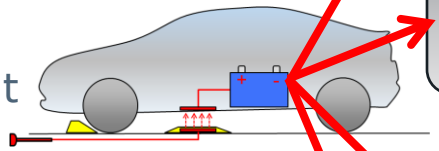
- Static applications (currently)
- Efficiencies of over 85% (Aligned)
- Air gaps up to 25 cm
- Safety Limits
- Validation Tests

SAE J2954 Task Force Testing Protocols

SAE Standard will Define:

- Performance
- Safety
- Testing Methodologies
- Charge Levels
- Location & Alignment
- Communications

SAE J2954 WPT Power Classes			
WPT1	**WPT2**	**WPT3**	**WPT4**
3.7 kW	7.7kW	11 kW	22 kW



EM Field

Safety Limits

- EMF Limits with AAMI
- EMC Limits

Performance

- Positions / Orientations
- Efficiency Power Transfer

Durability

- SAE J1211
- ISO 16750
- USCAR 37

Safety

- Object Detection
- Temperature Test
- Automatic Shutdown

SAE EV Charging Communication Standards

SAE Plug-In Electric Vehicle Grid Communication Standards

SAE J2836 ™ Use cases	Scope		Scope	SAE J2847 Detailed Info Messages
/1	Utility Programs *		Utility Programs *	/1
/2	Off-Board Charger Communications		Off-Board Charger Communications	/2
/3	Reverse Energy Flow		Reverse Energy Flow	/3
/4	Diagnostics		Diagnostics	/4
/5	Customer and HAN		Customer and HAN	/5
/6	Wireless Charging		Wireless Charging	/6

- Series of Standards defining Use Cases, Information Messages and Communication formats

SAE EV Charging Communication Standards

SAE Grid Communication Standards

SAE J2931	Scope
/1	Power Line Carrier Communications for Plug-in Electric Vehicles
/2	In-Band Signaling Communication for Plug-in Electric Vehicles
/3	PLC Communication for Plug-in Electric Vehicles
/4	Broadband PLC Communication for Plug-in Electric Vehicles
/5	Telematics Smart Grid Communications between Customers, Plug-In Electric Vehicles (PEV), Energy Service Providers (ESP) and Home Area Networks (HAN)
/6	Digital Communication for Wireless Charging Plug-in Electric Vehicles
/7	Security for Plug-in Electric Vehicle Communications

Establishes the requirements for digital communication between Plug-In Vehicles (PEV), the Electric Vehicle Supply Equipment (EVSE) and the utility or service provider

Battery Standards Technical Committees

- Started – 2009
- Committee Membership
  - >290 Individual Participants
  - >160 Companies
    - OEM's
    - Suppliers
    - Government
    - Academia
- 26 Subcommittees

NEW COMMITTEE

25) Battery Global Traceability

COMPONENTS & MATERIALS

23) Battery Systems Adhesives-Sealants-Heat Transfer Materials

21) Battery Thermal Management

19) Battery Systems Connectors

14) Battery Materials Testing

SUPPORT

4) Battery Transport

12) Battery Testing Equipment

13) Battery Terminology

3) Battery Labeling

LIFE MANAGEMENT

10) Battery Recycling

18) Battery Field Discharge & Disconnect

15) Secondary Use

24) Electric Vehicle Battery Service

PRODUCT SPECIFIC

2) Battery Standards Testing

1) Battery Safety

16) Start-Stop Battery

17) Capacitive Energy Storage

9) Future Energy Storage Systems

5) Battery Size Standardization

6) Starter Battery

8) Electronic Fuel Gauge

20) International Battery Interface

INDUSTRY SPECIFIC

7) Truck Battery

11) Small Task Oriented Vehicle Battery

22) Bus Battery

26) Micro-mobility Battery

Connected Vehicles

SAE Standards to Support Connected Vehicle Technologies

Focus Areas for Standards

- Mobile Devices
- Roadside Equipment
- Traffic Information Management
- Systems and Data Back Haul
- Service Providers
- Message Security
- Road Weather
- Curve Warning
- Traveler Information
- Work Zone Warning
- Maps
- Adaptive Signal Control
- Platooning
- Disabled / Vulnerable Road Users

Examples of Driver Alerts

- Forward Collision Warning
- Emergency Electronic Brake Light
- Intersection Movement Assist
- Blind Spot Warning
- Weather Warnings
- Lane Change Warning
- Do Not Pass Warning
- Right Turn in Front
- Signal Phase and Timing
- Curve Speed Warning
- Vulnerable Road Users

Use Cases: V2V V2IV V2 Other Vehicle Automation Center to Center Center to Field

V2X Communications Standards – Foundational Documents

J2735™ Message Set Dictionary

*** Document Update in Process**

- Defines Standardized Message Sets
- Supports Interoperability
- Defines Formats
- Defines Basic Safety Message (BSM)
- Defines MapData (Map) Message
- Defines Signal Phase and Timing Messages
- Defines Personal Safety Messages for VRUs
- Defines Traveler Information Messages (TIM)

J2945™ SEP Guidance for J2945/X Documents

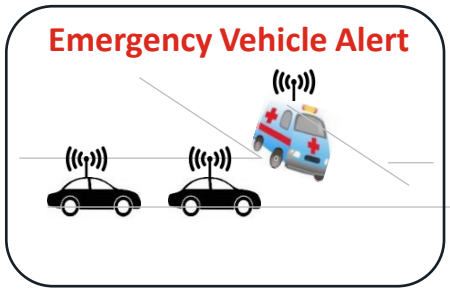
*** Document Update in Process**

- Provides System Engineering Guidance & Example
- Defines Communication Protocol
- Specifies Communication Performance Requirements
- Defines Message Transmission Rate
- Defines Channel usage
- Optional Data Usage
- Message Application Priorities

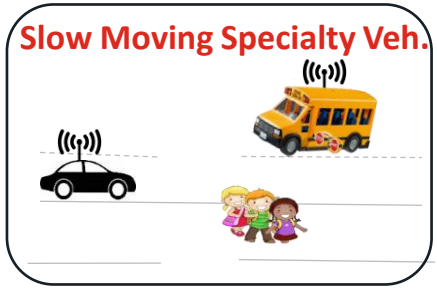
SAE J2945/2™ Performance Req's for V2V Safety Awareness

Defines the performance requirements for V2V Safety Awareness Performance

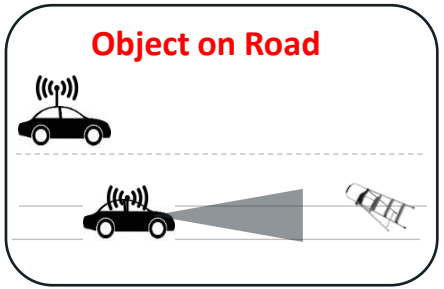
- **Covers four applications: Emergency Vehicle Alert, Roadside Alert, Safety Awareness Alerts for Objects, Adverse Road Conditions**
- **Includes needs and requirements, design, message and data messages**



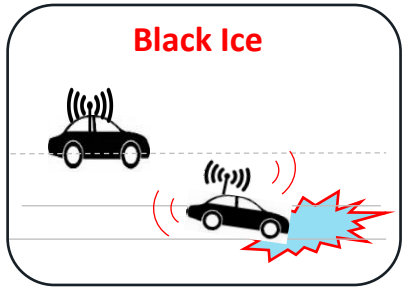
Safety Alert



Road Alert



Safety Awareness



Adverse Road Condition

SAE V2X Communication Documents

J2945/4™

Road Safety Applications (WIP)

- Infrastructure → Vehicle safety and mobility-related information
- Candidate applications:
  - Curve speed warning
  - Reduced speed warning
  - Lane & Road changes/closures
  - Interoperability & performance

J2945/7™

Positioning Enhancements for V2X Systems (WIP)

- Addressing use cases that require high levels of position accuracy, reliability, and integrity
- Supports integration of high-precision GNSS receivers and other positioning systems

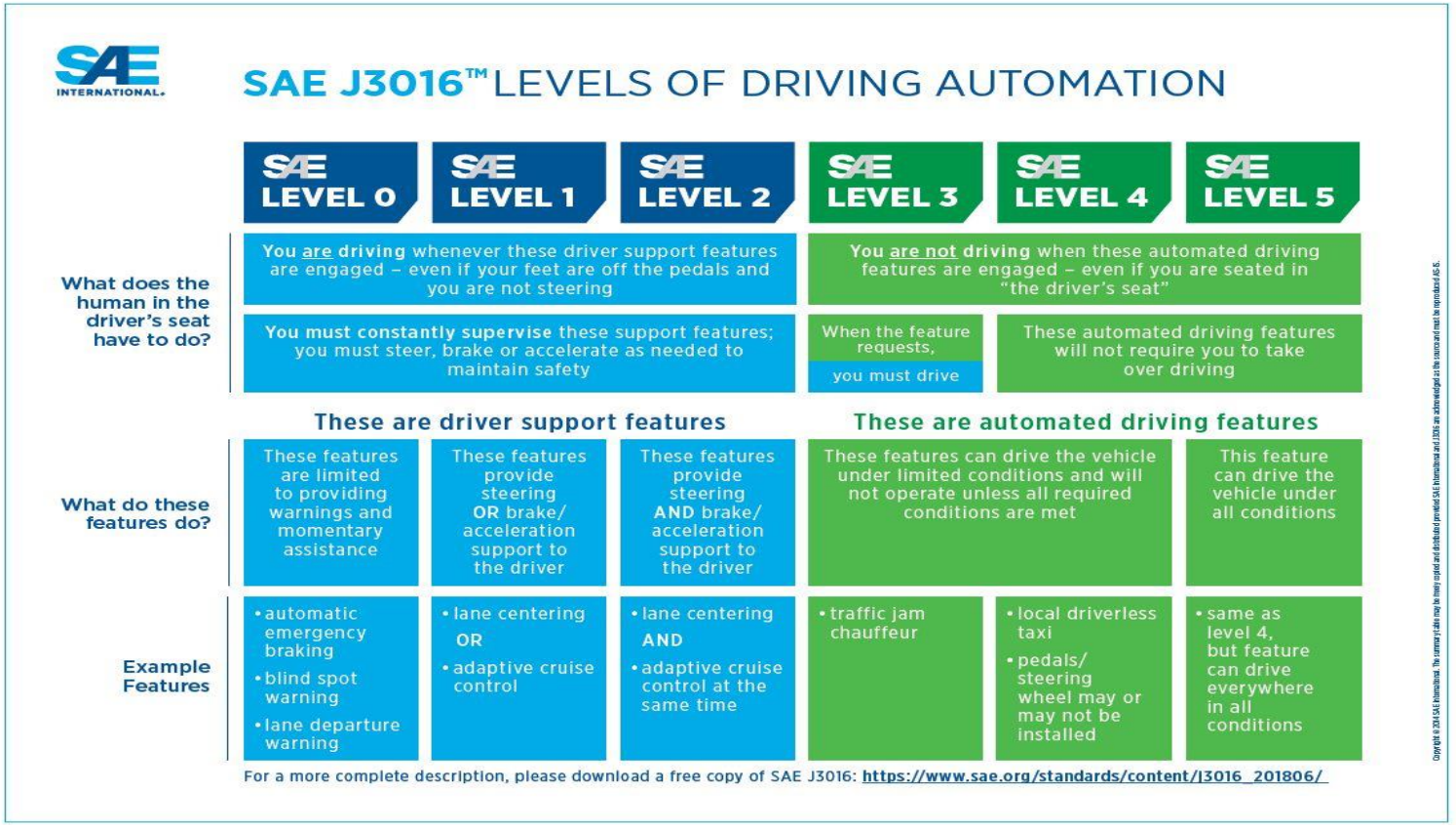
J2945/8™

Cooperative Perception Systems (WIP)

- Describes methods for a V2X device to broadcast perception information of other road users/objects nearby
- Defines use cases, performance & security requirements

Driving Automation Standards

SAE J3016™ Consumer Version



SAE INTERNATIONAL

SAE J3016™ LEVELS OF DRIVING AUTOMATION

	SAE LEVEL 0	SAE LEVEL 1	SAE LEVEL 2	SAE LEVEL 3	SAE LEVEL 4	SAE LEVEL 5
What does the human in the driver's seat have to do?	You are driving whenever these driver support features are engaged – even if your feet are off the pedals and you are not steering			You are not driving when these automated driving features are engaged – even if you are seated in "the driver's seat"		
	You must constantly supervise these support features; you must steer, brake or accelerate as needed to maintain safety			When the feature requests, you must drive	These automated driving features will not require you to take over driving	
	These are driver support features			These are automated driving features		
What do these features do?	These features are limited to providing warnings and momentary assistance	These features provide steering OR brake/ acceleration support to the driver	These features provide steering AND brake/ acceleration support to the driver	These features can drive the vehicle under limited conditions and will not operate unless all required conditions are met		This feature can drive the vehicle under all conditions
Example Features	• automatic emergency braking • blind spot warning • lane departure warning	• lane centering OR • adaptive cruise control	• lane centering AND • adaptive cruise control at the same time	• traffic jam chauffeur	• local driverless taxi • pedals/ steering wheel may or may not be installed	• same as level 4, but feature can drive everywhere in all conditions

For a more complete description, please download a free copy of SAE J3016: https://www.sae.org/standards/content/j3016_201806/

Read the 40+ page document!

Automated Vehicle Safety Consortium™

A Program of SAE ITC

Informs AV pilot projects/deployments

Leverages safety expertise and creates a culture of safety

Accelerates formal global standards

Implemented by our member organizations

Available to everyone

https://avsc.sae-itc.com/

Aurora cruise gm TORC Uber VOLKSWAGEN GROUP OF AMERICA WAYMO ZOOX

SAE Driving Automation Standards

TERMS & DEFINITIONS

Safety

RECOMMENDED PRACTICES

TEST & VERIFICATION METHODS

On-Road Automated Driving (ORAD) Committee

J3247_202403 • Automated Driving System Test Facility Safety Practices
J3131_202203 • Definitions for Terms Related to Automated Driving Systems Reference Architecture
J3171_201911 • Identifying Automated Driving Systems-Dedicated Vehicles (ADS-DVs) Passenger Issues for Persons with Disabilities
J3018_202012 • Safety-Relevant Guidance for On-Road Testing of Prototype Automated Driving System (ADS)-Operated Vehicles
J3206_202107 • Taxonomy and Definition of Safety Principles for Automated Driving System (ADS)
J3164_202301 • Taxonomy and Definitions for Terms Related to Automated Driving System Behaviors and Maneuvers for On-Road Motor Vehicles
J3016_202104 • Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles (Revision *Initiated: March 24, 2023)*

Cooperative Driving Automation (CDA) Committee

J3256_202403 • Cooperative Driving Automation (CDA) Feature - Infrastructure-Based Prescriptive Cooperative Merge
J3251_202308 • Cooperative Driving Automation (CDA) Feature: Perception Status Sharing for Occluded Pedestrian Collision Avoidance
J3282_202406 • Cooperative Infrastructure CDA Feature: Cooperative Permissive Left Turn Across Opposing Traffic with Infrastructure Guidance
J3252_202308 • Process for Developing an Interoperable Cooperative Driving Use Case Test Framework and Test Procedures
J3216_202107 • Taxonomy and Definitions for Terms Related to Cooperative Driving Automation for On-Road Motor Vehicles (Revision *Initiated May 12, 2023)*

Driving Automation Systems (DAS) Committee

J3114_201612 • Human Factors Definitions for Automated Driving and Related Research Topics

SAE Driving Automation Standards – Works In Process

Safety

RECOMMENDED PRACTICES

TEST & VERIFICATION METHODS

On-Road Automated Driving (ORAD) Committee

J3261 Resources for accommodating the needs of persons with disabilities when using ADS-DV

J0911 First Responder Interactions with Fleet-Managed Automated Driving System-Dedicated Vehicles (ADS-DVs)

J3237 Driving Assessment (DA) Metrics for Automated Driving Systems

J3320 SAFETY MANAGEMENT SYSTEM (SMS) Application to SAE Level 3, 4, 5 ADS – equipped Vehicles and Supporting Systems

J3279 Best Practices for Developing and Validating Simulations for Automated Driving Systems

J3016 Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles

J3208 Taxonomy and Definitions of ADS V&V

J3018 Safety-Relevant Guidance for On-Road Testing of Prototype Automated Driving System (ADS)-Operated Vehicles

J3259 Taxonomy & Definitions for Operational Design Domain (ODD) for Driving Automation Systems

Driving Automation Systems (DAS) Committee

J3114 Human Factors Definitions for Automated Driving and Related Research Topics

J3196 Describing human roles and capabilities as part of driving automation systems

SAE Driving Automation Standards – Works In Process

Safety

RECOMMENDED PRACTICES

TEST & VERIFICATION METHODS

Cooperative Driving Automation (CDA) Committee

J3316 Cooperative driving automation (CDA) Features: Common reference architecture, nomenclature and template

J3216 Taxonomy and Definitions for Terms Related to Cooperative Driving Automation for On-Road Motor Vehicles

Connected Transportation Interoperability (CTI) Committee

J5001 Onboard Unit Standard for Connected Vehicles

J2945/B Recommended Practices for Signalized Intersection Applications

J3305 Assured Green Period to Support Red Light Violation Warning

J3258 V2X Infrastructure Support for GNSS Corrections

J3295 Cooperative Perception Services Concept of Operations

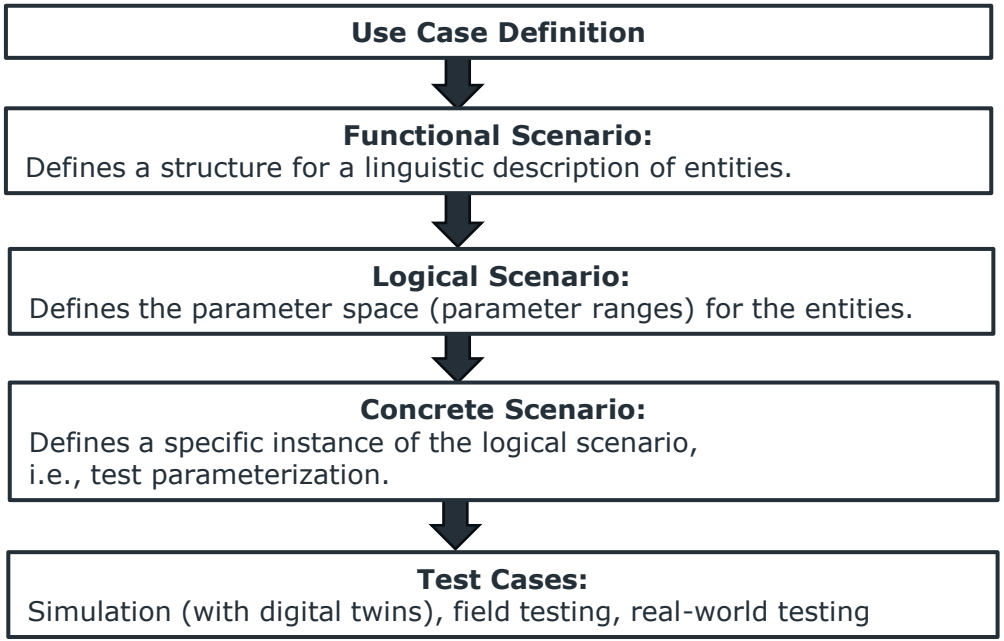
J4501 Connected Intersections (CI) Implementation Guide v2.0

J3238/1 Testing & Validation of SPaT information broadcast from Connected Intersections to support in-vehicle Red Light Violation Warning

J3238/2 Testing & Assessment of MAP using RTCM information broadcast from Connected Intersections to support in-vehicle Red Light Violation Warning

CDA: Use Case Development Framework

Machine-to-machine (M2M) communication technologies foster cooperation between two or more traffic participants. Shared information is used to coordinate movement, or change state (e.g., a traffic signal) reducing risk of conflicts and facilitating each traffic participant's mobility goals.



Safety metrics

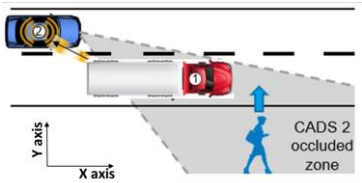
Cooperative messages & event flow

Design architectures

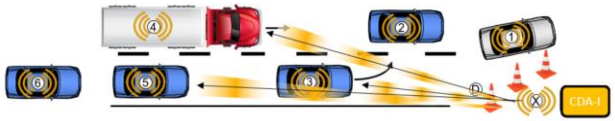
Testing standards & Success criteria

Cooperative Driving Automation: Use Cases

SAE J3251: Perception Status Sharing for Occluded Pedestrian Collision Avoidance

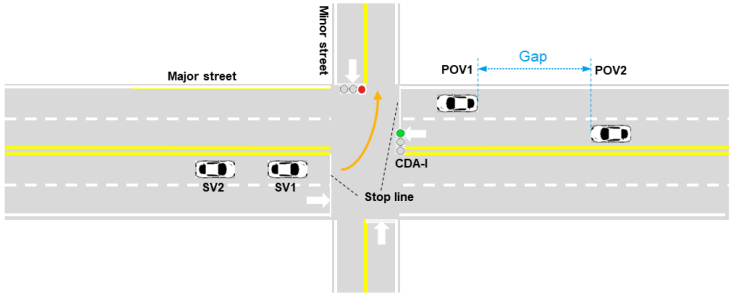


SAE J3256: Infrastructure-Based Prescriptive Cooperative Merge



SAE J3282: : Cooperative Permissive Left Turn with Infrastructure Guidance

- ✓ Safety metrics
- ✓ Design logic / algorithms
- ✓ Success criteria
- ✓ Cooperative message and event flow:
  - ✓ The solution can be deployed today
  - ○ Potential solution for the future



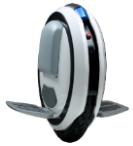
Powered Micromobility

SAE Low-Speed Micromobility Devices Committee

Electric Kick Scooter

Electric Skateboard

Segway



Electric Self-Balancing Unicycles

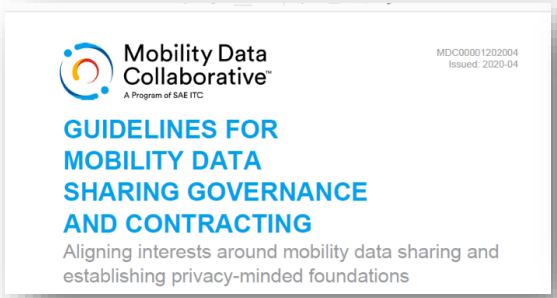
This committee focuses on low-speed personal, vocational, and delivery mobility devices and the technologies and systems that support them. These may be device-propelled or have propulsion assistance.

Emerging and innovative mobility vehicles and devices, sometimes referred to as micro-mobility, are proliferating in cities around the world.

These technologies have the potential to expand mobility options for a variety of people.

The SAE Micromobility Battery Committee focuses specifically on battery and charging needs.

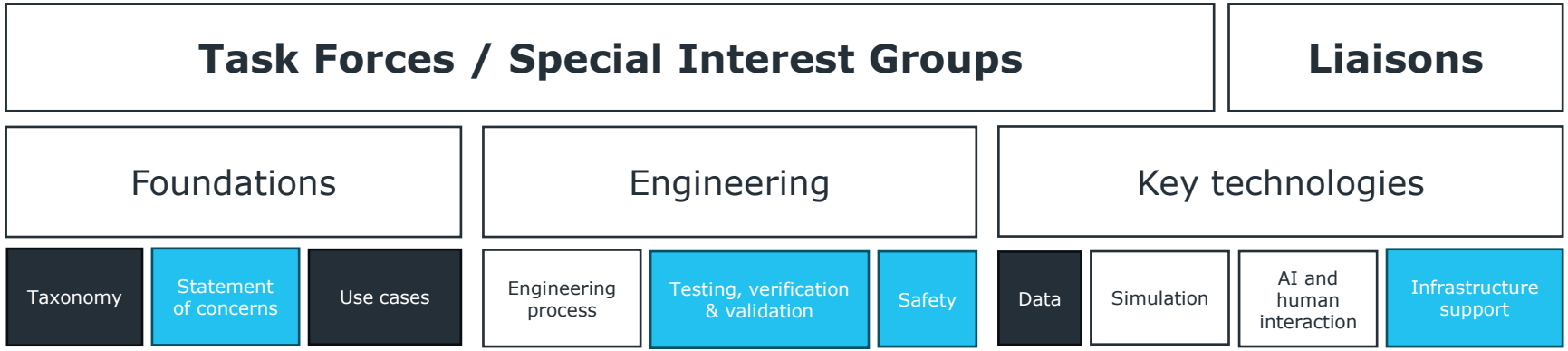
Micromobility and MaaS



Artificial Intelligence

SAE Ground Vehicle AI Committee

Mobility, Advanced™

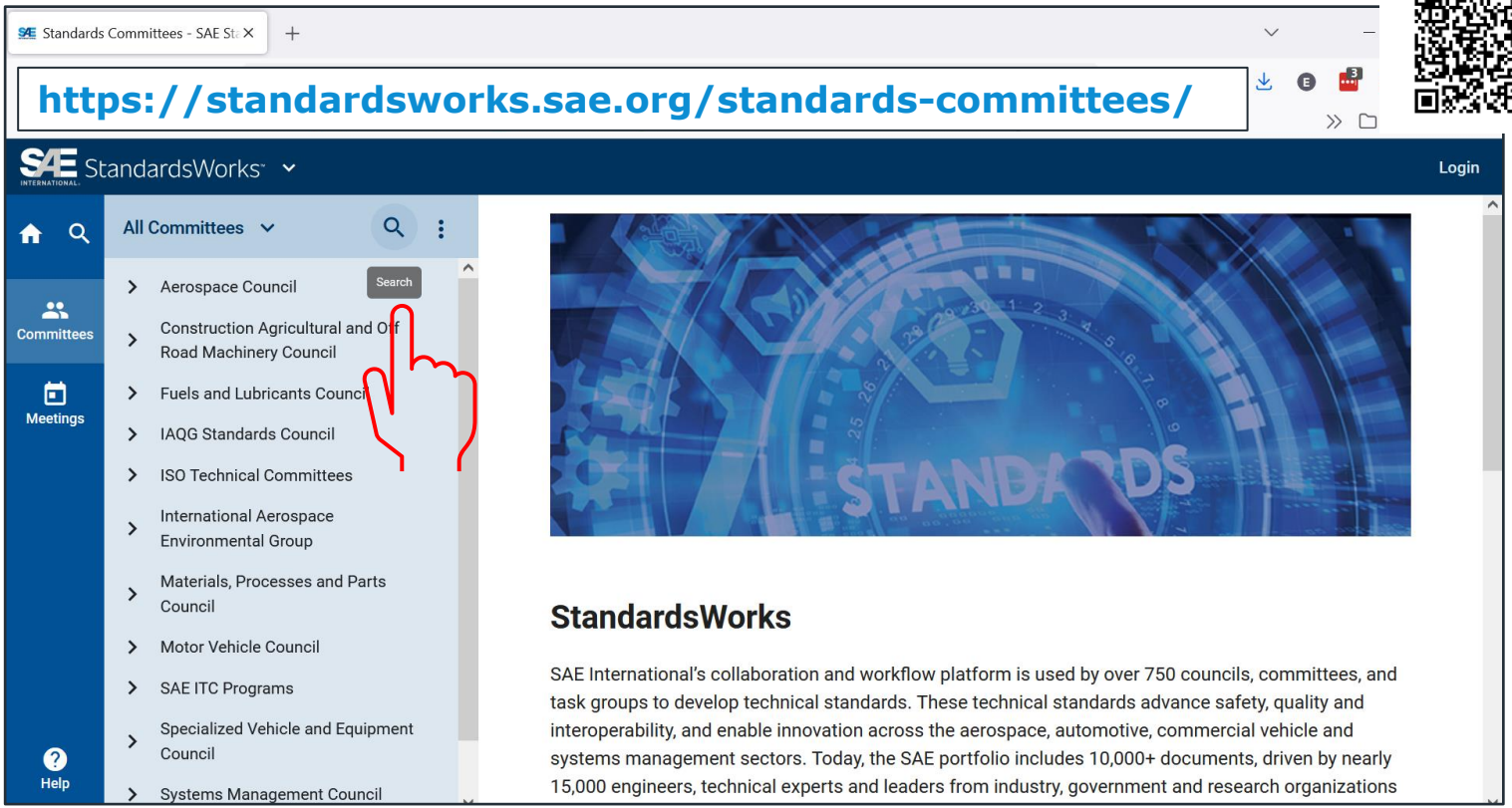


- TF/SIG with an active document under development
  - J3313: Artificial Intelligence - Terms & Definitions Taxonomy
  - J3312: Artificial intelligence (AI) — Use Cases in Ground Vehicle Applications
  - J3298: Ground Vehicle Artificial Intelligence Data Information Report
  - J3321: Verification & Validation of AI/ML based Components & Systems in Ground Vehicles
- Focus areas for new document development in 2024

Working with SAE

Global Standards Collaboration

Get Involved Technical Committees & Research



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Get involved

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