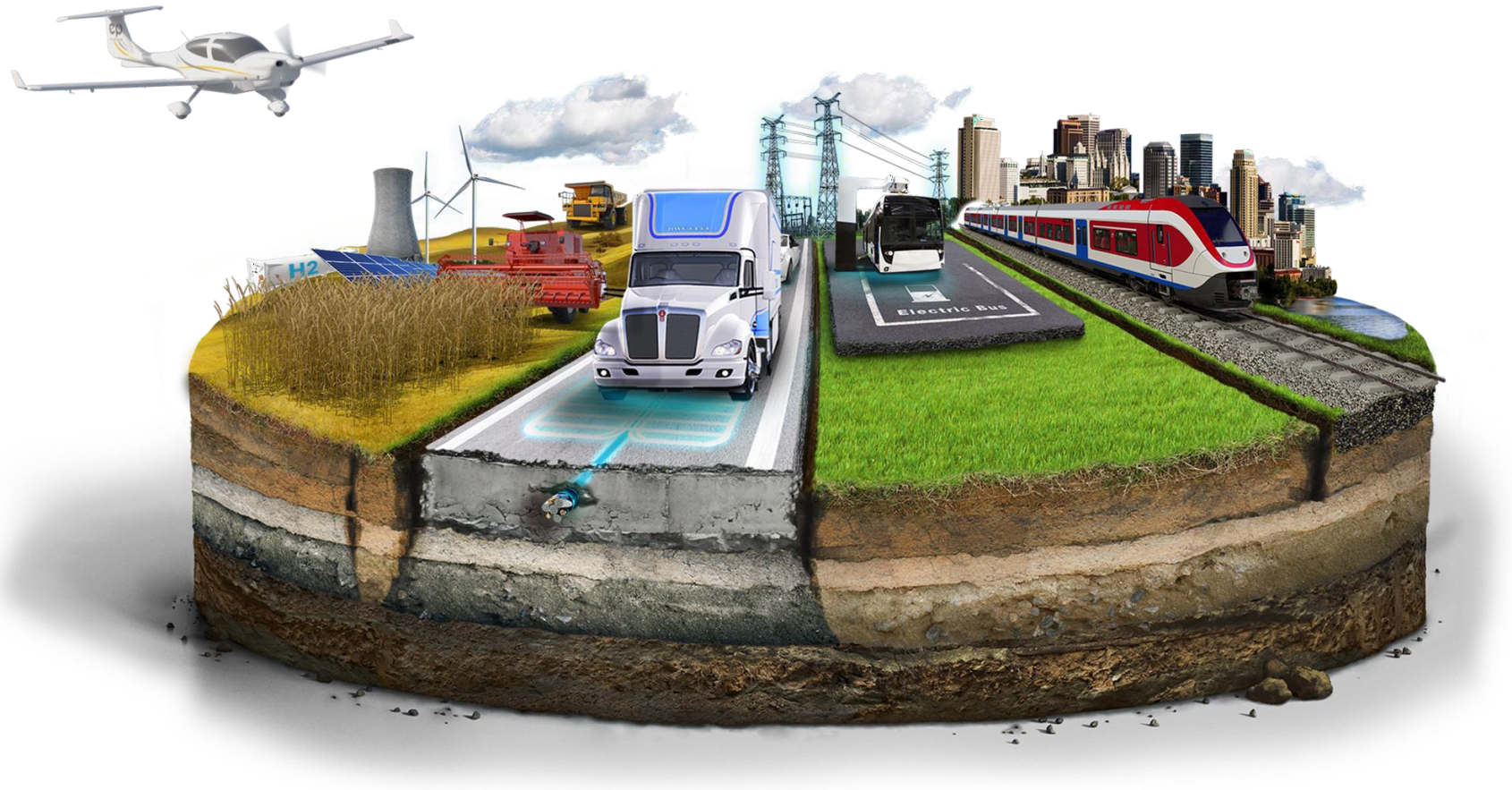
ASPIRE

NSF Engineering Research Center

Advancing Sustainability through Powered Infrastructure for Roadway Electrification



ASPIRE Overview

Abhilash Kamineni
Assistant Professor

Don Linford
Innovation Director

August 2023

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NSF Engineering Research Center

Advancing Sustainability through Powered Infrastructure for Roadway Electrification

https://aspire.usu.edu/

Started in 2020 as a multi-disciplinary effort across five core Universities and over 60 partners

Utah State University

University of Colorado Boulder

UTEP

Purdue University

The University of Auckland, New Zealand

Vision: Sustainable and Equitable Future for Transportation

Widespread Electrification Across Vehicle Classes and Adoption Groups

Reduce GHG Emissions
Improve Human Health
Improve Human Prosperity
Improve Equity and Access

Co-optimized power and transportation networks

Smart charging across vehicle classes and user groups

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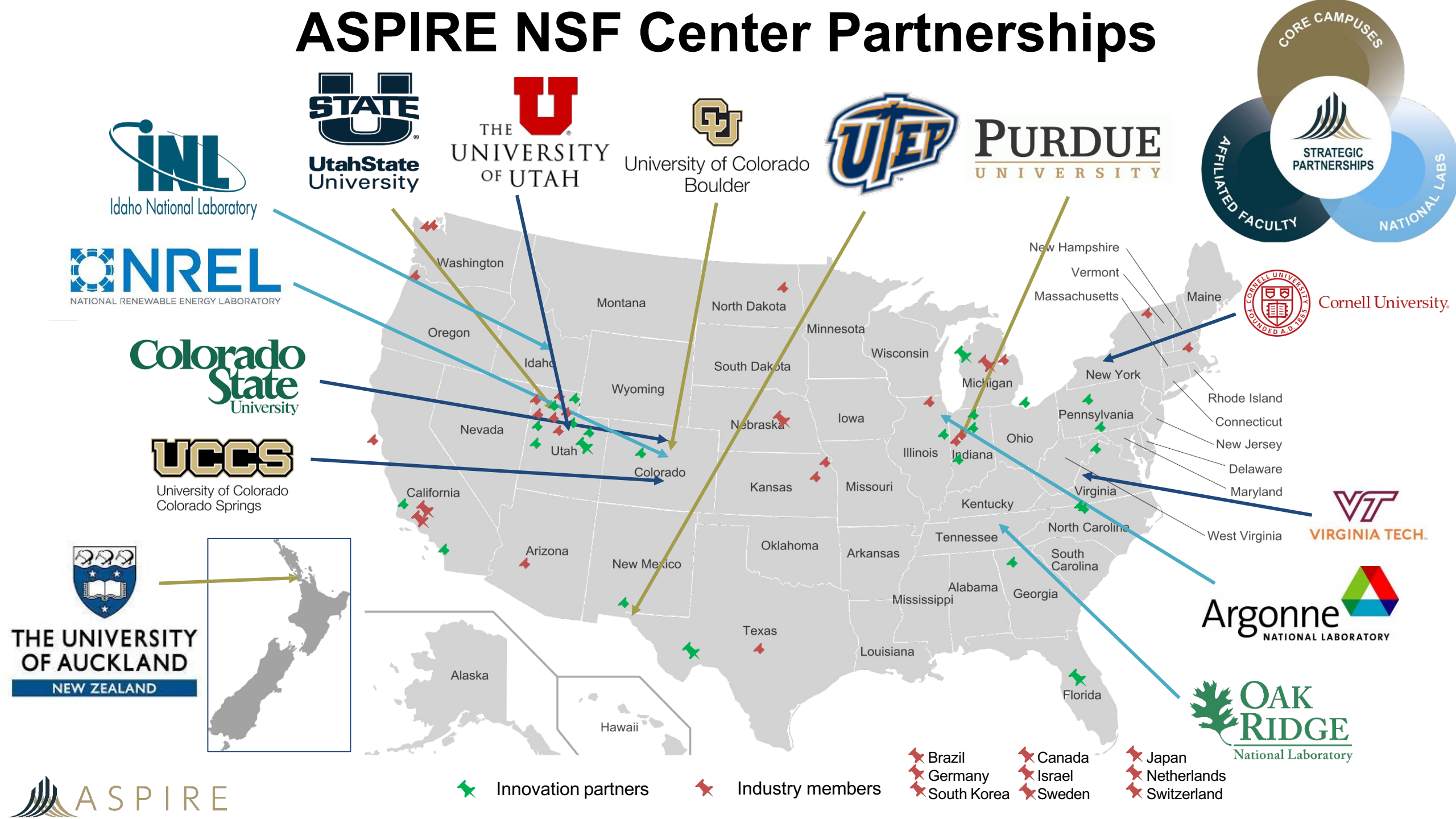
Synergy with connected and autonomous vehicles

Wired and wireless charging systems bring power to the vehicle

Community Driven | High Utilization

ASPIRE NSF Center Partnerships



Industry Members

Innovation Members

Convergent Research Thrusts & Projects

Research Thrusts

Transportation

Transportation Systems
Transportation Infrastructure

Adoption

User Acceptance / Society
Public Policy / Economy
Techno-economics

Power

Power Systems / Grid Integ.
Charging Systems
Battery Systems

Equity

Social Equity
Environmental Justice
Technology & K-22 Education

Data

Data Analysis & Fusion
AI / Optimization / Co-sim
Cybersecurity / IoT / Networks

Center Projects

- Charging Stations of the Future
- Electric Roads
- City & Inter-City Scale Systems
- Learning & Engagement

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Systems of Systems Testbeds

Electric Vehicle and Roadway (EVR)

- ¼-mile electrified test track
- 128 kW solar power, 100 kW/kWh battery, 750 kW utility service, 250 kW battery test
- Stationary and in-motion wireless and wired charging, grid integration, real-time grid-vehicle interaction
- Expansion: Heavy duty trucks and HIL
- Key resource for EWD-DCI activities

Full Scale City & Intercity Simulator

- Expansive co-simulation, synthetic models of grid, traffic, charging, & society
- Quantified analysis of the interactions between technology and society (policy, incentives, demand response, pricing, behavior & choice, economics, adoption)
- HIL linked to EVR hardware testbed
- Publicly released by Year 10

EVR Expansion / ASPIRE Headquarters

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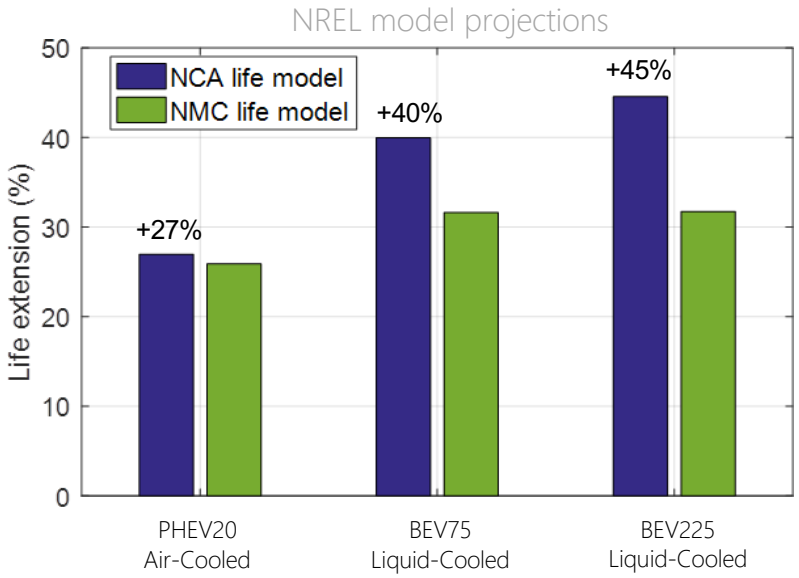
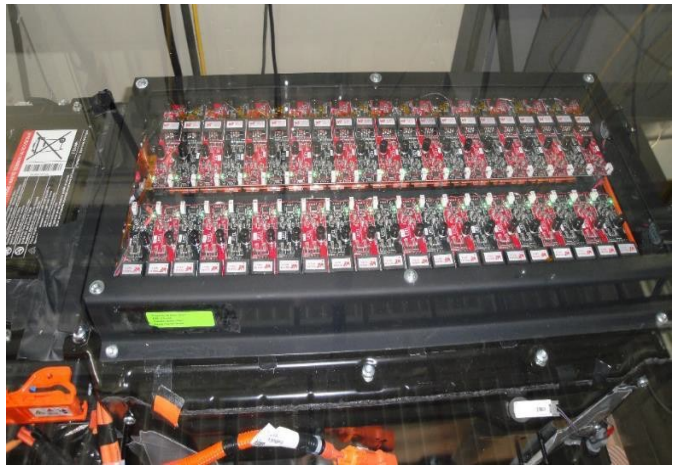
Examples of Technology Developments

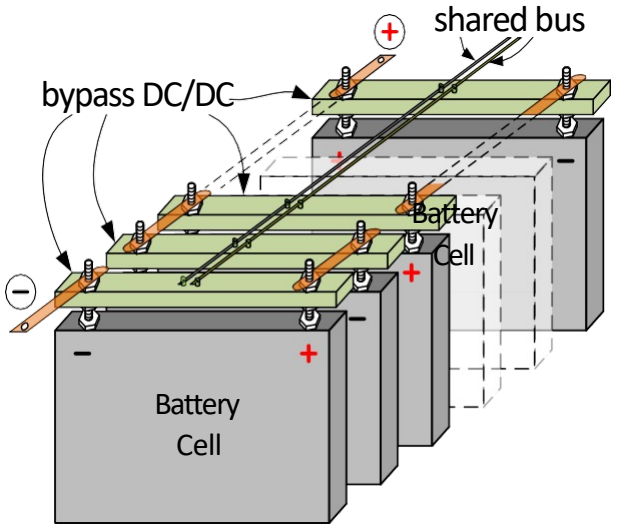
Smart Active Battery Management: Making Batteries Last Longer





Ford C-Max Energi 8 kWh battery pack retrofitted with smart cell-level battery management technology

- Modular, scalable battery systems
- Low-cost dc-dc converters perform cell-level control using physics-based cell models
- Up to 45% longer xEV battery pack lifetime at reduced system cost and volume
- Enabling use of reduced-cost cells, and second-life cell applications



UtahState University

University of Colorado Boulder

UCCS University of Colorado Colorado Springs

Ford NREL NATIONAL RENEWABLE ENERGY LABORATORY

arpa·e

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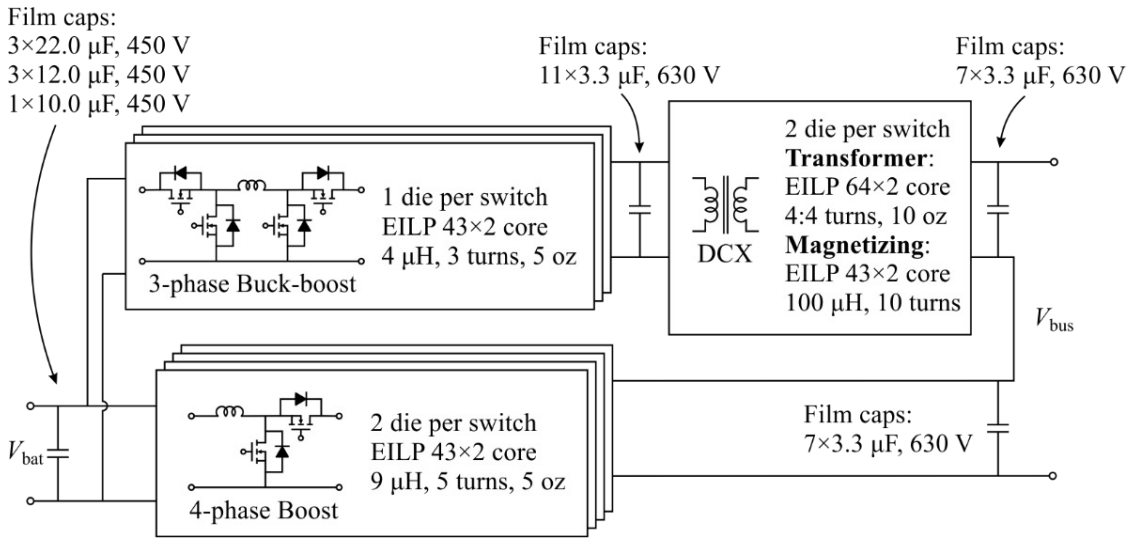
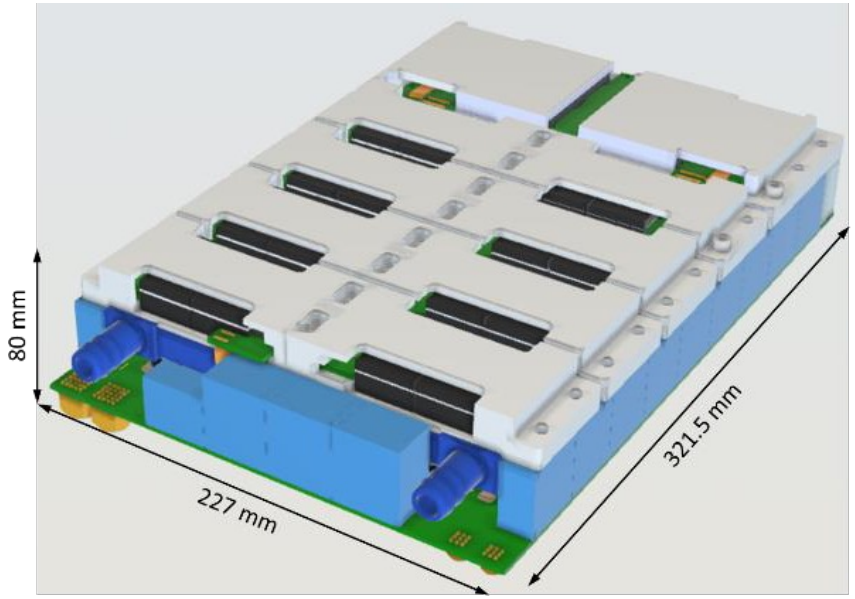
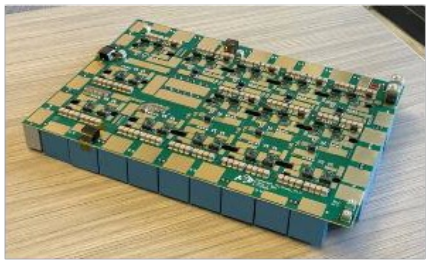
Examples of Technology Developments

Ultra High Density, Ultra High Efficiency xEV Power Electronics







125 kW, 200-to-1200 V, 21.3 kW/L Composite DC-DC xEV Converter Prototype

- 99% drive-cycle weighted efficiency
- Innovative converter architecture with 900 V SiC switches
- 4 x reduced losses and 4 x reduced size compared to the state of the art

University of Colorado Boulder · TOYOTA RESEARCH INSTITUTE · UAF · NREL NATIONAL RENEWABLE ENERGY LABORATORY · Wolfspeed A CREE COMPANY · arpa·e U.S. DEPARTMENT OF ENERGY

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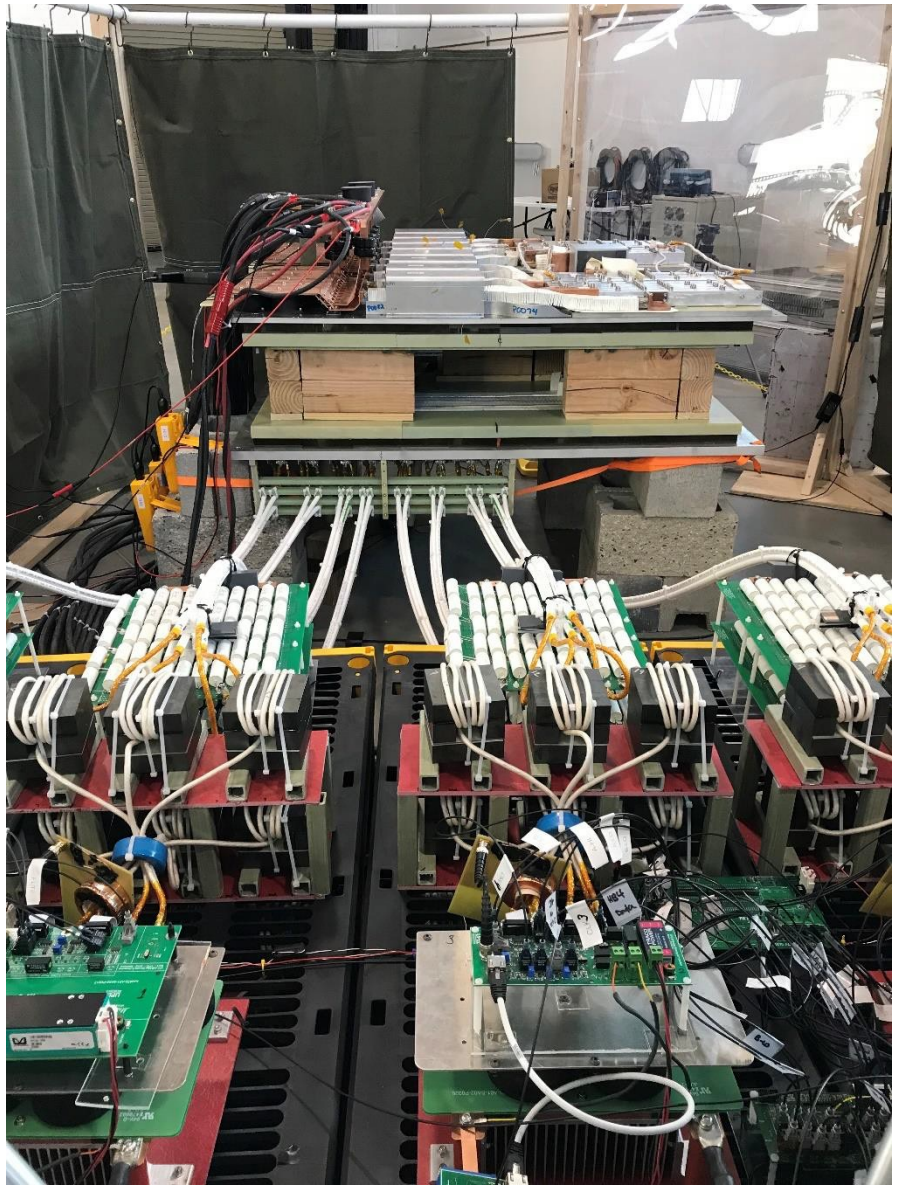
Examples of Technology Developments

1MW Wireless Power System Prototype

Objectives: effective electrification of heavy-duty vehicles

Demonstrated prototype capabilities:

- 850 kW power transfer demonstrated
- 95% dc-dc efficiency
- Single pad smaller than 2 m^2



UtahState University

WAVE
Wireless Advanced Vehicle Electrification

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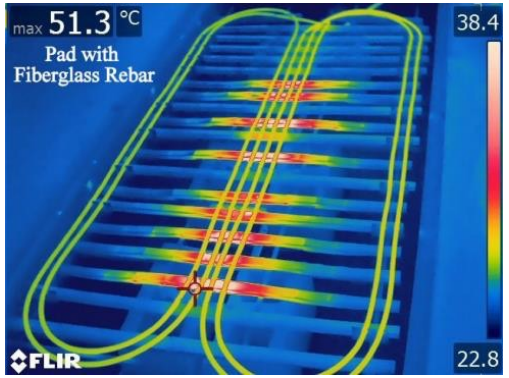
Examples of Technology Developments

Electrified Roadway Components

In-motion wireless charging and autonomous control of the “Aggie Bus” on the EVR track



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UtahState University

UTEP

PURDUE UNIVERSITY

THE UNIVERSITY OF AUCKLAND
NEW ZEALAND

2022, 2023+ Testbeds: Pre-pilot Activities

2022

electreon

Electreon 25 kW+ x 3
50m DWPT

THE UNIVERSITY OF AUCKLAND
NEW ZEALAND

UoAuckland WPT pad

MAGMENT

Magment 50 kW
10m DWPT
2023

STATE U

- Removable track segments
- Test rail, 100 kW modules
- Rav 4 integration
- 50 kW IPP concrete pads x 3
- Aggie Bus Demo
- EMS & charge management
- Heavy duty truck integration

2023

IPT TECHNOLOGY
Powered by EVOLGY

IPT 200 kW
40m DWPT

Purdue
200 kW DWPT
2024

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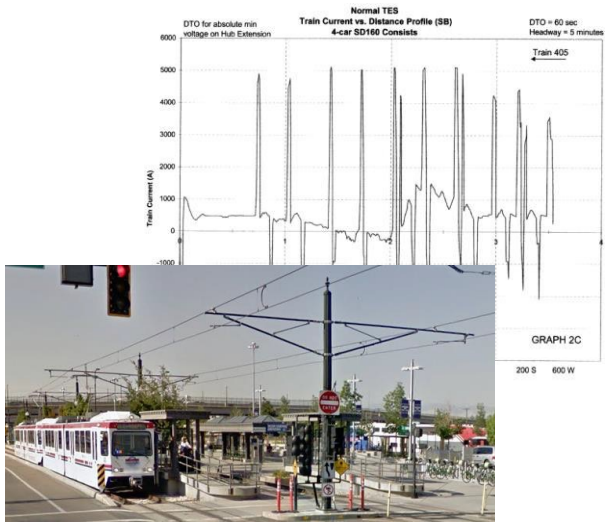
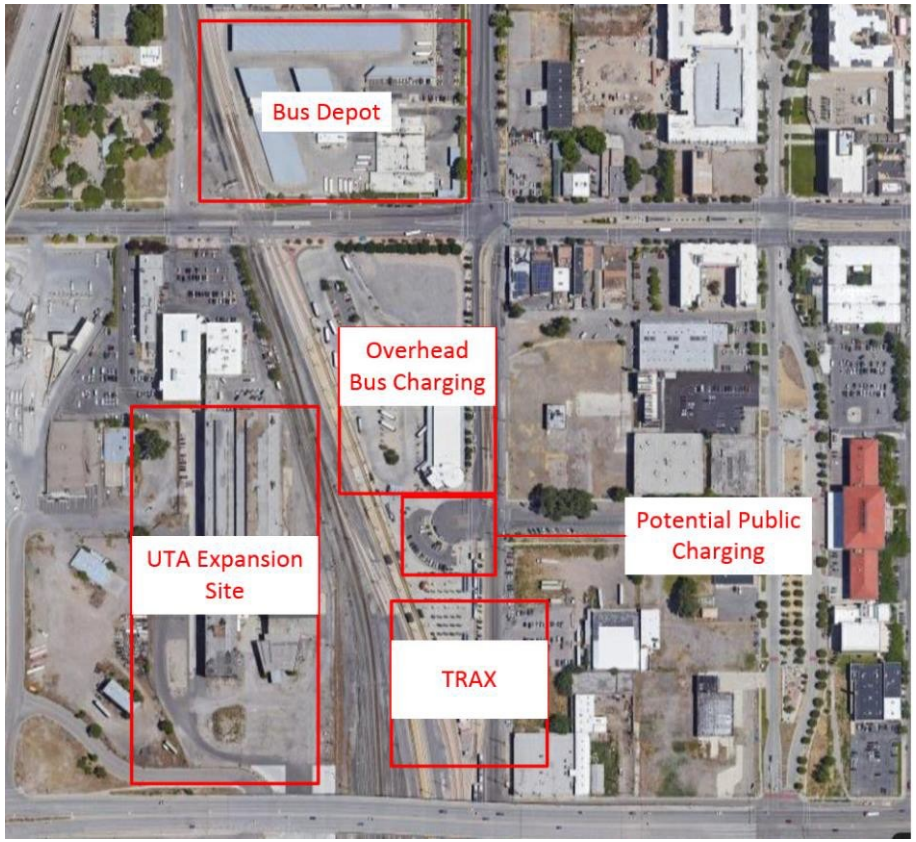
Intermodal Hub Pilot Project



TRAX line, predictable MW-level pulsed load

Intermodal Hub facility variable demand



2x 450 kW overhead bus chargers and 3x 50 kW bus depot chargers

2x 150 kW public DC fast charging

Smart charge management AI algorithm development for planning and run time optimization tools

Increase utilization, reduce demand charges, defer upgrade costs, provide grid services

Planning, algorithm development, software and hardware deployment, pilot and field evaluation

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Inland Port Freight Electrification Demonstration Project

Lays the groundwork for electrified transportation in Utah to improve air quality and stimulate economic growth

Inland Port is an ideal candidate to demonstrate capabilities for heavy duty vehicles and prepare “shovel-ready” projects for upcoming federal infrastructure funds

3-year project with Pre-Pilot Development, Infrastructure Build, and Pilot Demonstration provides validated full scale port electrification plan

Pilot infrastructure will be used long term in port electrification

Union Pacific Intermodal Facility moves 1M cargo containers per year

Demonstrate electric “hoteling” for semis to reduce overnight diesel pollution

Demonstrate site-level smart charge management to improve utilization and reduce cost

Demonstrate plug-in, static and dynamic wireless charging of heavy duty trucks and fork lifts

Leverage significant private and federal cost share

Committed commercial partners (vehicle & infrastructure)

USU-ASPIRE Pre-Pilot

Vehicle, infrastructure, and communications systems integration and evaluation in controlled environment with commercial partners

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PURDUE UNIVERSITY

ASPIRE

MAGMENT
CONCRETE WIRELESS POWER

Wireless EV charging via highway pavement to be tested in Indiana

STEPHEN EDELSTEIN JULY 26, 2021 View Gallery

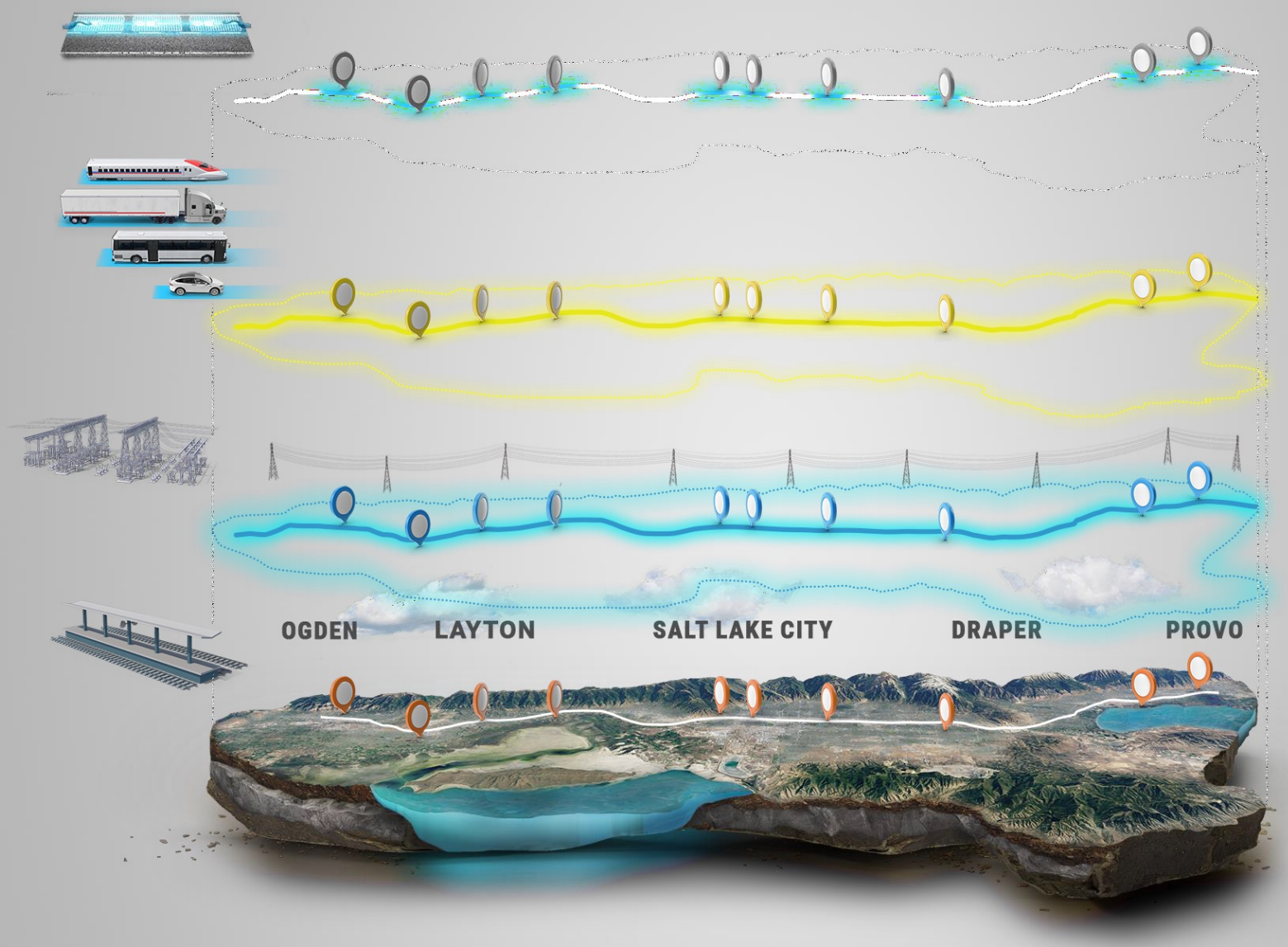
Full-scale Dynamic Wireless Power Transfer and Pilot Project Implementation

INDIANA DEPARTMENT OF TRANSPORTATION
INDOT

JOINT TRANSPORTATION RESEARCH PROGRAM
Discovery with Delivery Since 1937
JTRP

Research Team:
Profs. John Haddock
Nadia Gkritza,
Dionysios Aliprantis,
Steve Pekarek

Coordinated Multi-modal Electrification



Commuter and light rail serve as roadmap for intermodal charging hubs

Multi-megawatt substations at hubs with coordinated grid loading

Fast charging networks and hydrogen generation leverage rail infrastructure for trucks, buses, and passenger vehicles

Electric roads leverage shared rail & road infrastructure along corridor

Shared public infrastructure with load management reduces cost and emissions for all transportation