SAE INTERNATIONAL

EV WIRELESS POWER TRANSFER, THE PATH TO COMMERCIALIZATION THROUGH STANDARDS

-SAE J2954-

PRESENTED BY: IVO TEERLINCK
CO-LEAD INTEROPERABILITY SUBTEAM

JESSE SCHNEIDER
SAE TASKFORCE CHAIR
WIRELESS POWER TRANSFER AND ALIGNMENT METHODOLOGY

OUTLINE:

Standardization Path to Commercialization

Wireless Power Transfer for PHEV & EVs

SAE J2954 Overview

Timeline

Testing with Industry & US DOE

Conclusion

Why Wireless Power Transfer?

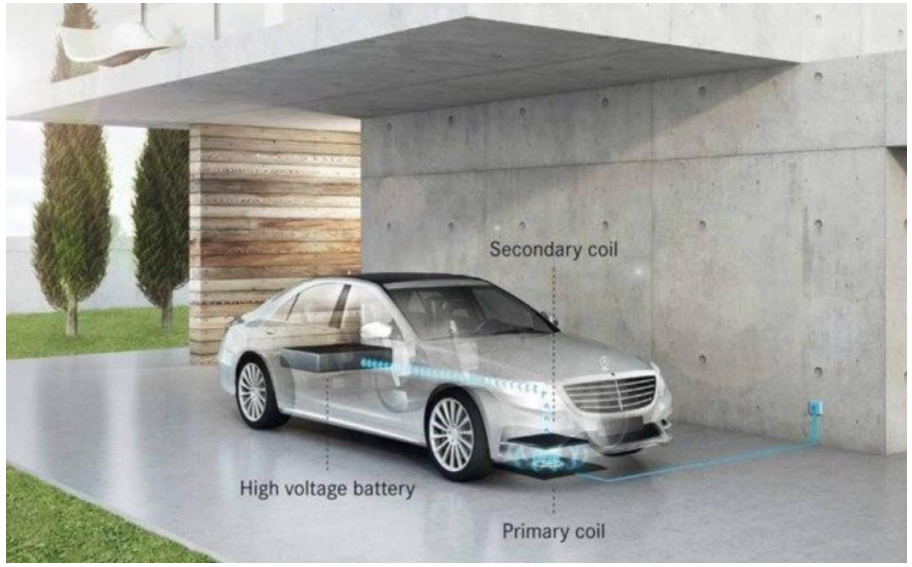
Electric Vehicles are the future

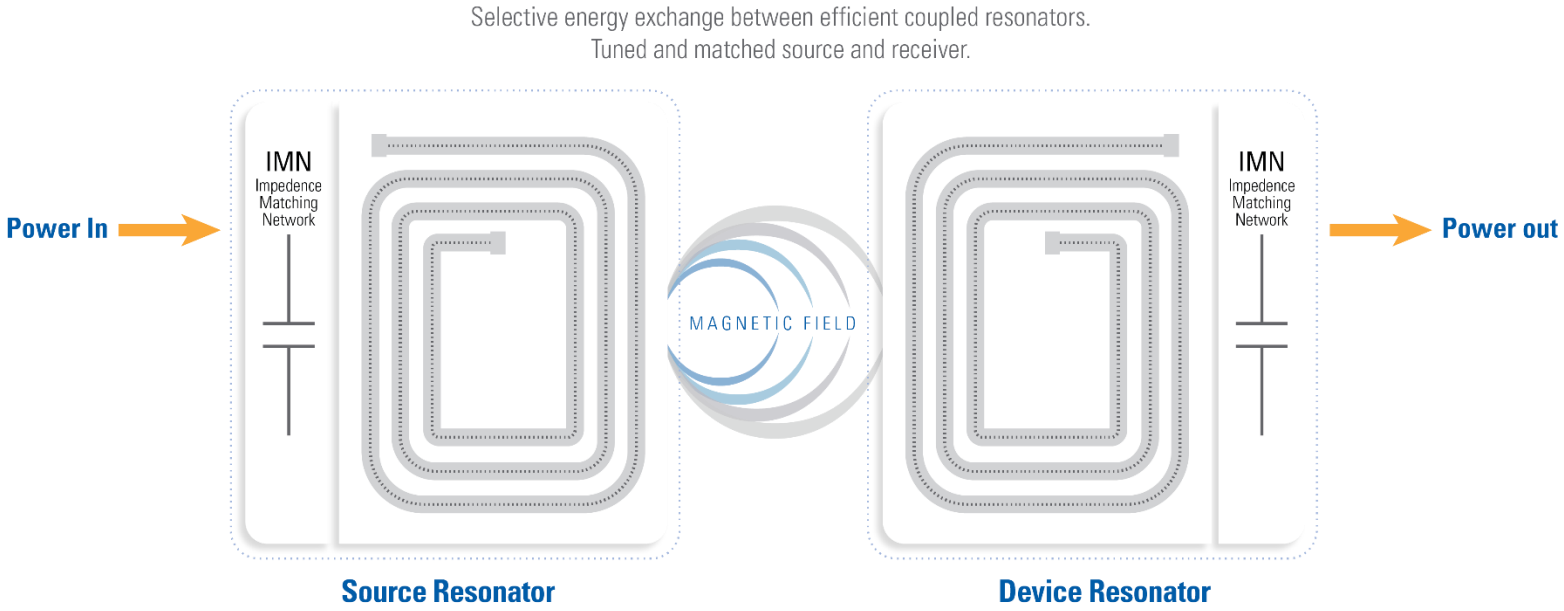



… but why do we have to plug in? If you forget, you may not be using your car until it is charged.

What is the alternative?

What is Wireless Power Transfer?





PHEV / EV Power Transfer Input Levels: 3.7 – 22 kW (WPT 1-4)

Vehicle Clearance Ranges: 100 – 250 mm

AC-Battery Efficiency: >85%, Up to 94% shown in testing

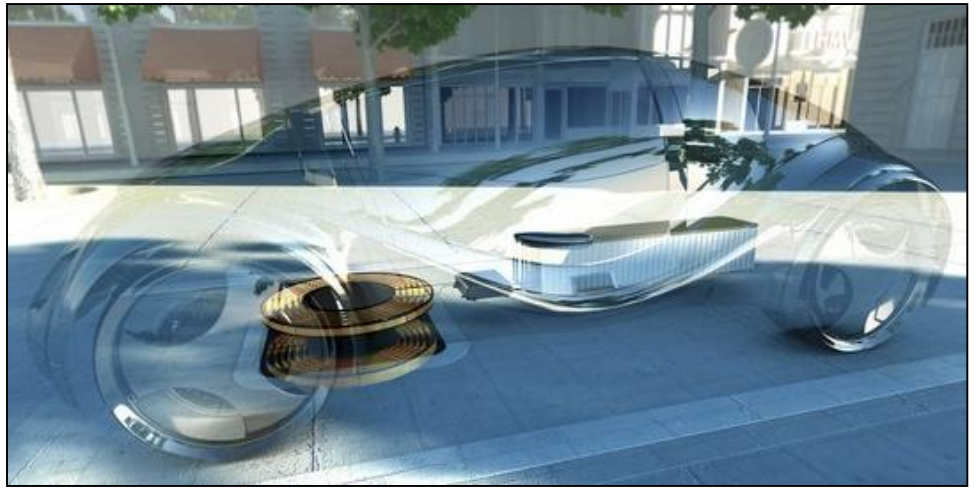
Automakers,Tier 1's, & Suppliers

Auto OEMs:

- BMW
- Daimler
- Fiat Chrysler
- Ford
- GM
- Honda
- Jaguar
- Karma
- Mitsubishi
- Nissan
- Toyota

Bus OEMs:

- BYD
- Gillig
- Proterra
- Scania
- Volvo



OEM Tier 1 & Technology Suppliers

- Delphi
- Lear
- LG
- Magna
- Panasonic
- TDK
- Toshiba
- Evatran
- Momentum Dynamics
- Qualcomm Halo
- SEW
- Wave
- Wireless EV Charge
- WiTricity

Other Participating Entities in J2954

Government Groups

- US DOE
- US FCC
- US FDA
- US DOT (NHTSA)
- US National Laboratories: INL, ANL, ORNL, EDL
- JARI (Japan)
- Kaist (Korea)

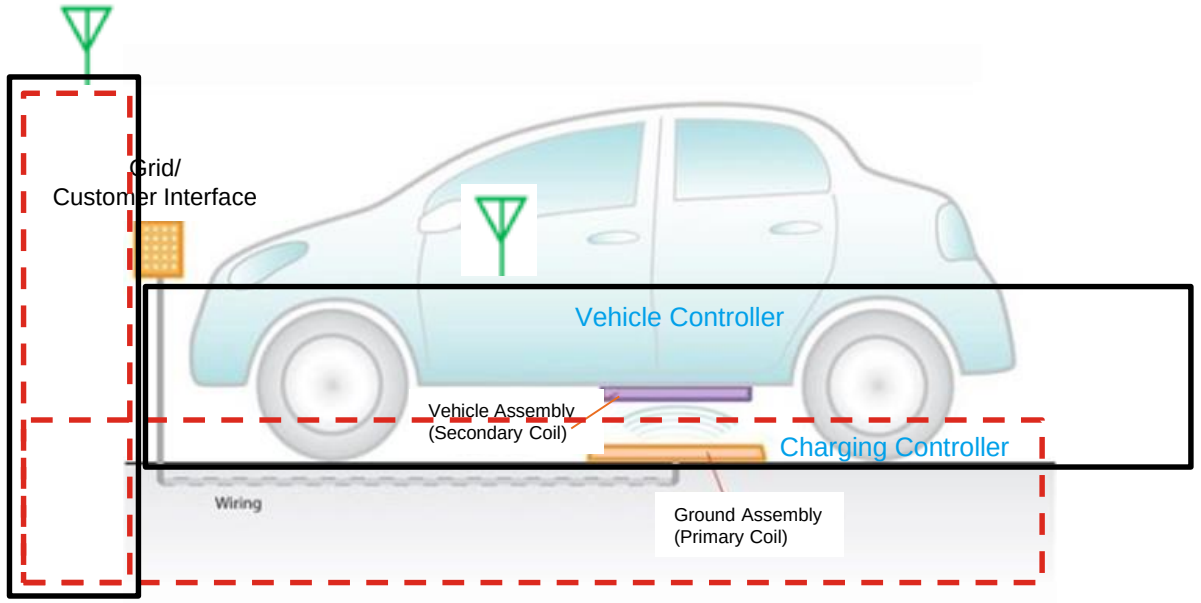
Other Groups

- American Association of Medical Instrumentation (AAMI)
- EPRI
- ISO 19363 (MOU in Process)
- Universities (Aukland, Colorado, Michigan, Utah,etc.)
- UL (MOU Established)
- TÜV North America

Vehicle Wireless Charging Standards

Overlap with SAE J2954, SAE J2836/6 UL 2750

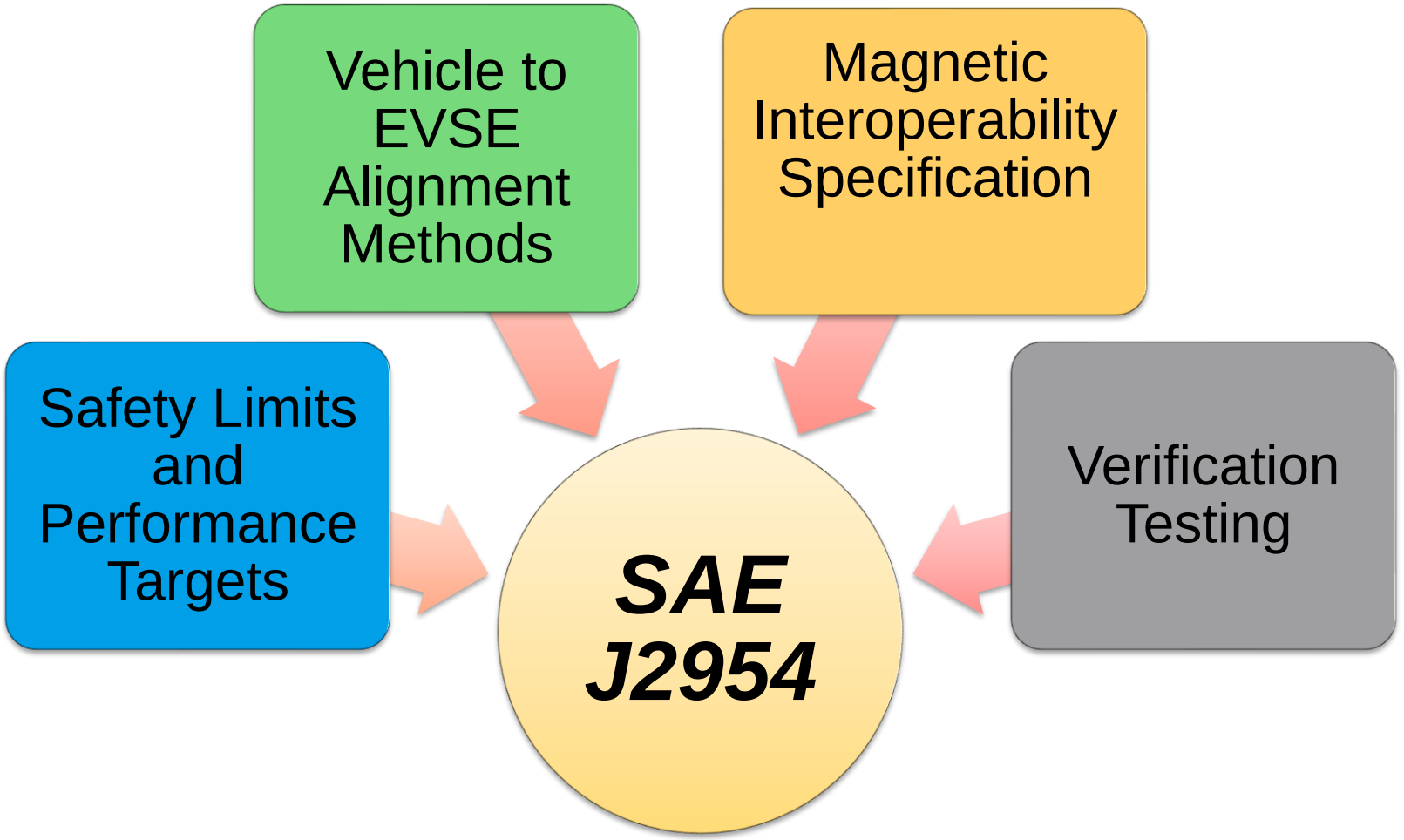
SAE J2836/6: Use Cases and Communications
SAE J2847/6: WPT Communication PHEV and the Utility Grid
SAE J2931/6: Digital Communication for WPT for PHEV



UL 2750: Verification of Wireless Charging Base Safety (Draft)

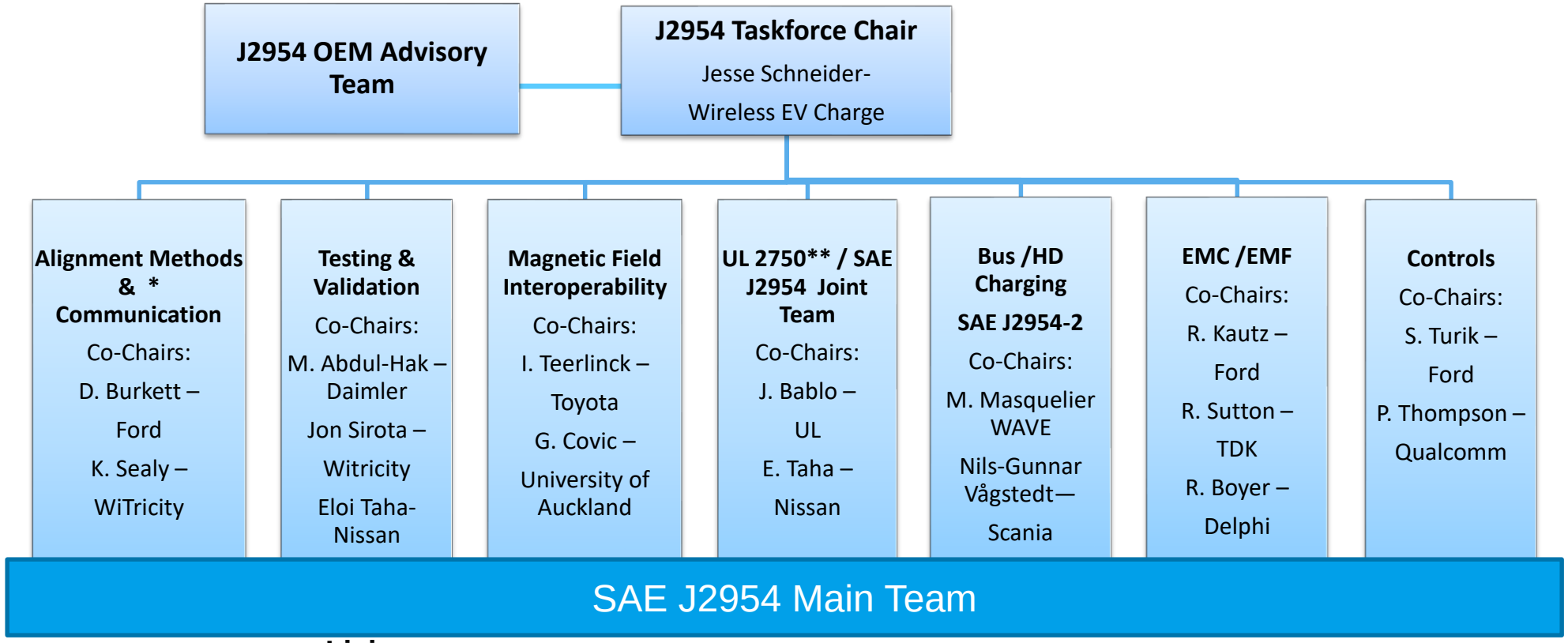
SAE TIR J2954: Wireless Power Transfer and Alignment

SAE J2954 SCOPE



Technical Information Report (2016)→ Recommended Practice (2017) → Standard (2018)

SAE J2954 Taskforce Structure: OEM / Supplier Co-Chairs



Liaisons:

ISO**/IEC : J. Sirota (Witricity)/ I. Teerlinck (Toyota)
AAMI/ ANSI/CISPR: R. Boyer (Delphi) / Sutton (TDK RF)
FCC/FDA: Schneider / Kautz / Sutton / Boyer

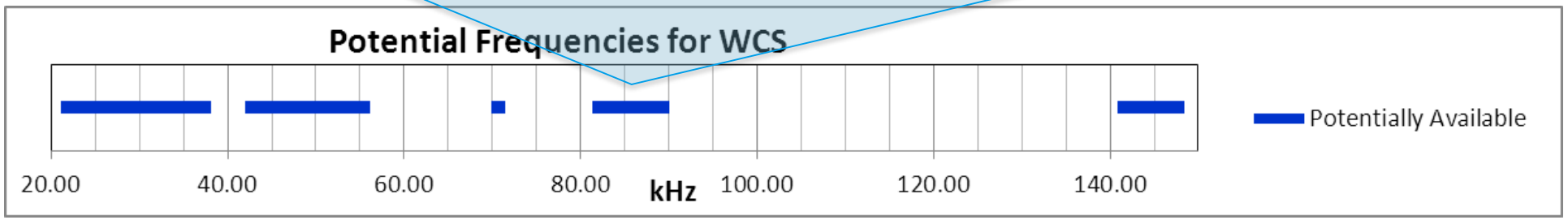
*In Coordination with ISO & SAE Hybrid Communications & DSRC Committees
**SAE J2954 MOU with UL established. ISO MOU under discussion.

SAE J2954 Light Duty WPT Frequency Decision

“85kHz”Frequency Band Decision for SAE J2954 :

Interoperability: Frequency

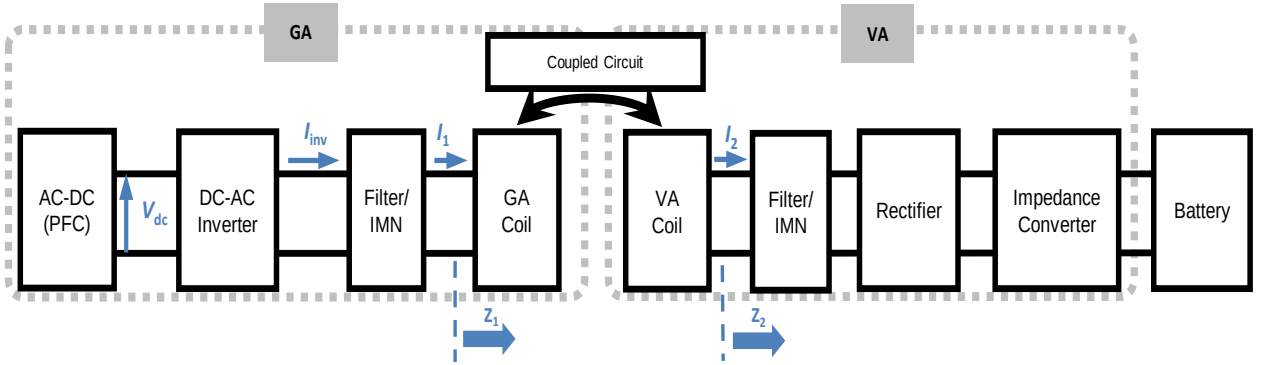
	Start of Band (kHz)	End of Band (kHz)
Light Duty Vehicles	81.38	90.00



SAE J2954 Taskforce WPT Power Classes

	L.D. WPT Power Classes*			
	WPT1	**WPT2**	**WPT3**	**WPT4**
Maximum Input Power	3.7 kW	7.7kW	11kW	22 kW[1]
Minimum target efficiency	>85% Aligned			

* J2954/2, The Heavy Duty WPT 4 is under evaluated for higher power levels.

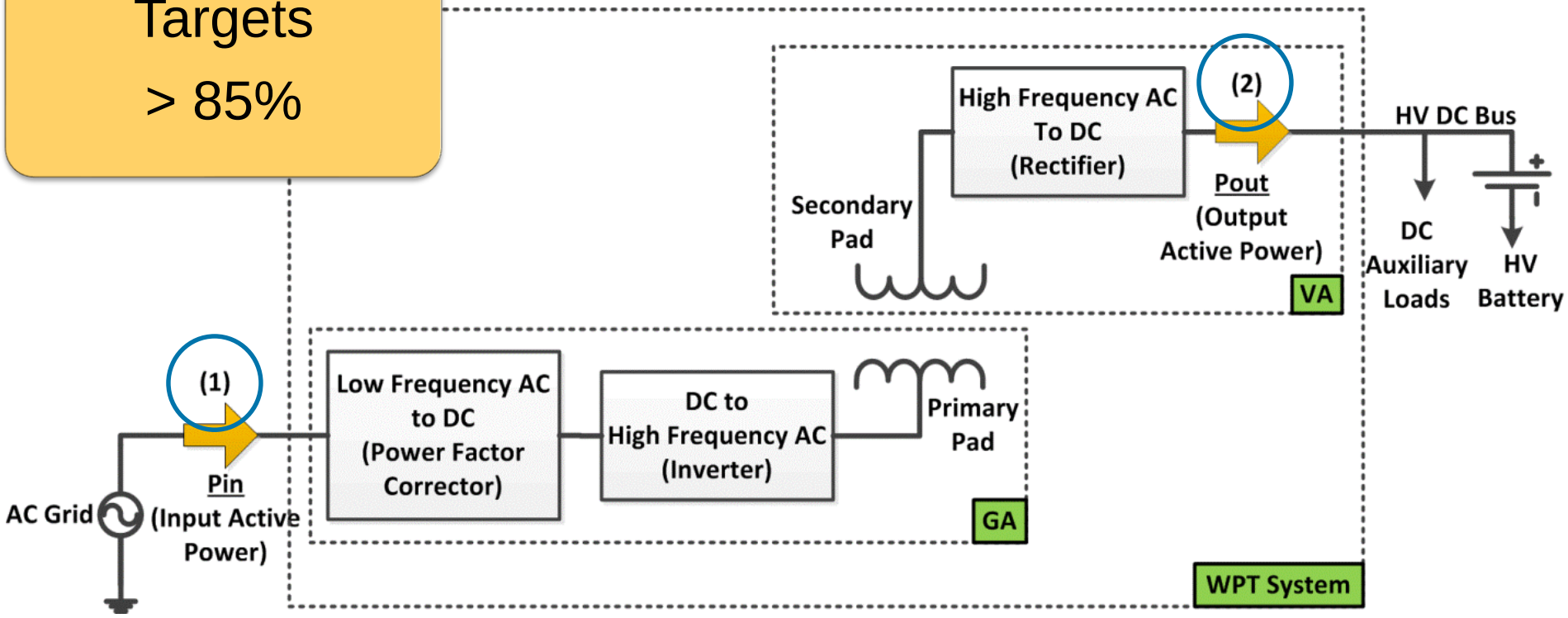


Interoperability Classes/ Performance Targets

SAE J2954 WPT System Efficiency

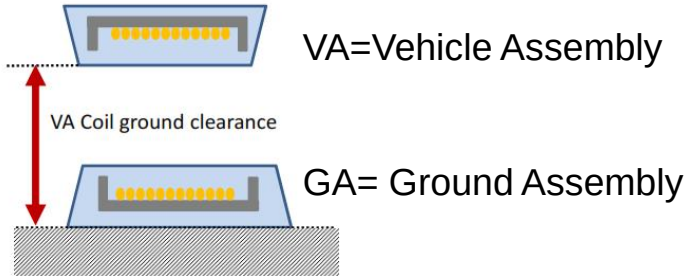
Performance Targets

> 85%



WPT Efficiency is determined as percentage of the active power supplied by the AC grid that feeds the traction battery and low voltage auxiliary loads connected to the high voltage (HV) DC bus of the vehicle based on input and output active powers measured at points (1) and (2).

SAE J2954 TIR WPT Z-Classes



Specification of the Z-classes for Above Ground Mounting

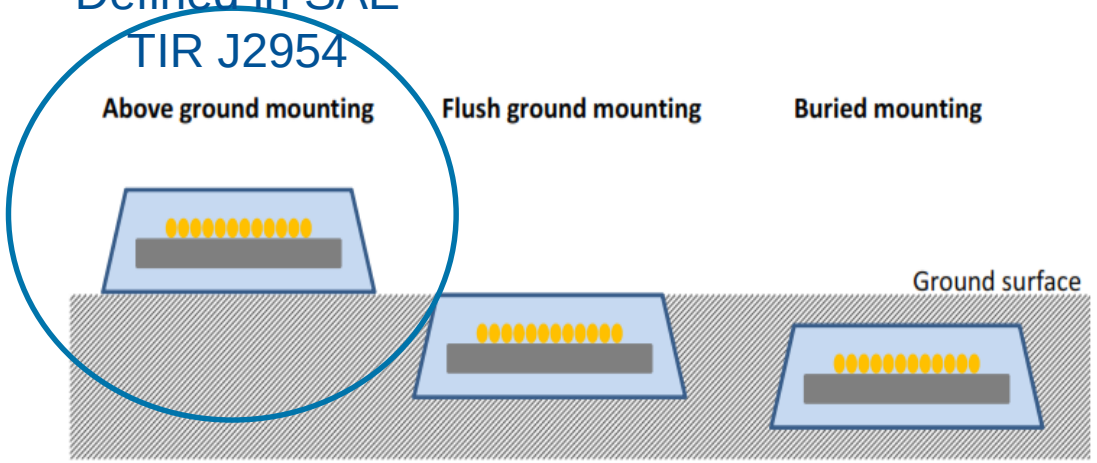
Z-Class	Vehicle Assembly (VA) Coil ground clearance range (mm)
Z1	100 – 150
Z2	140 – 210
Z3	170– 250

Interoperability:

Mounting and Height Classes

Mounting Categories

Defined in SAE TIR J2954



To be defined in SAE J2954 Standard

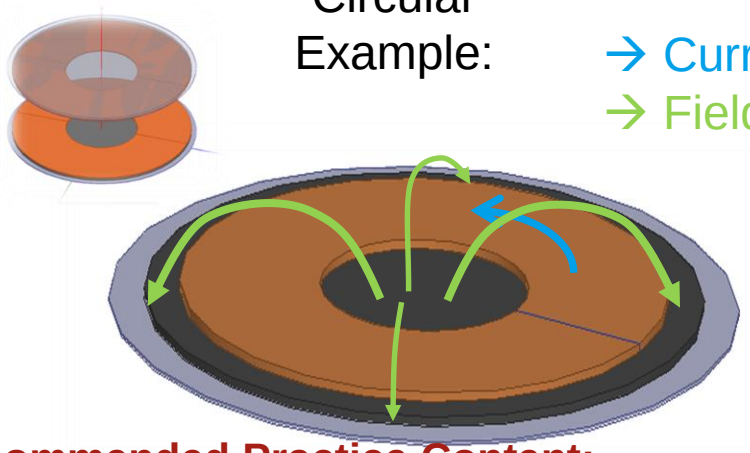
J2954 WPT Standard Test Coil Specification:

- Common characteristics
  - Coupling is via the Reactive Near Fields (like a transformer).
  - Typically, both primary & secondary coils are resonant.

- Example: Circular / Square Coupler
  - Vertical Dipole Moment (aligned)
  - +Horizontal Dipole Moment (misaligned)
  - “non-polarized” (higher order moments dominant at coupling distance)

Circular Example:

→ Current
→ Field



SAE J2954 Recommended Practice Content:

WPT 1 VA / GA: Testing Coil / Circular Topology
WPT 2 VA / GA: Testing Coil / Circular
WPT 2 VA / GA: Reference/ D-D Topology
WPT 3 VA/GA: Reference Circular/ D-D Topology

Interoperability: Coil Specification

- Recommended Practice SAE J2954 specifies the WPT Vehicle Assembly and Ground Assembly Reference Coils Test Coils to WPT 2, 7.7kW.
  - Guideline for OEMs and Infrastructure Suppliers for the testing phase of the technology.

SAE Test Project 2017-2018:

- Confirmation of interoperability, EMF, EMC limits with different supplier WPT Ground Assembly WPT 3, 11kW
- Initial testing has already confirmed magnetic interoperability up to WPT 2, 7.7kW

J2954 WPT 1, Z1*, Z2 Coil Specification:

“Master Coil Set”: Circular Topology

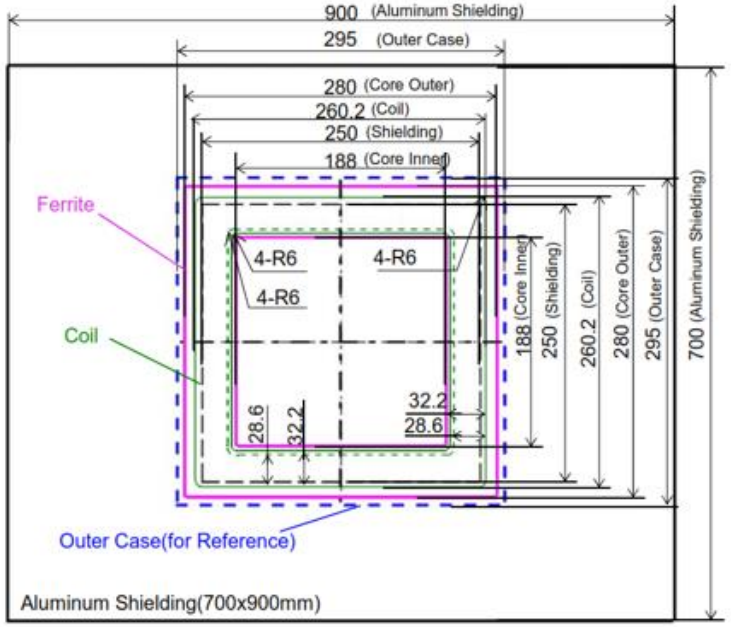


Figure Am1: Mechanical dimensions of the M-VA-WPT1/Z1.

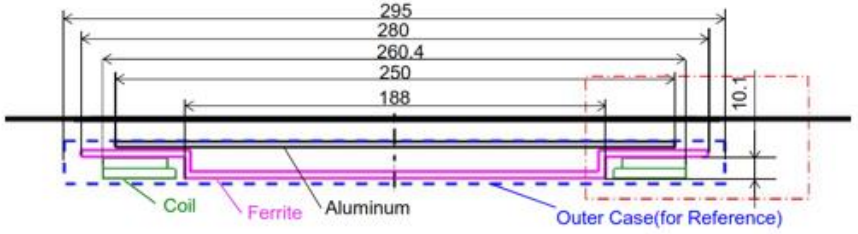
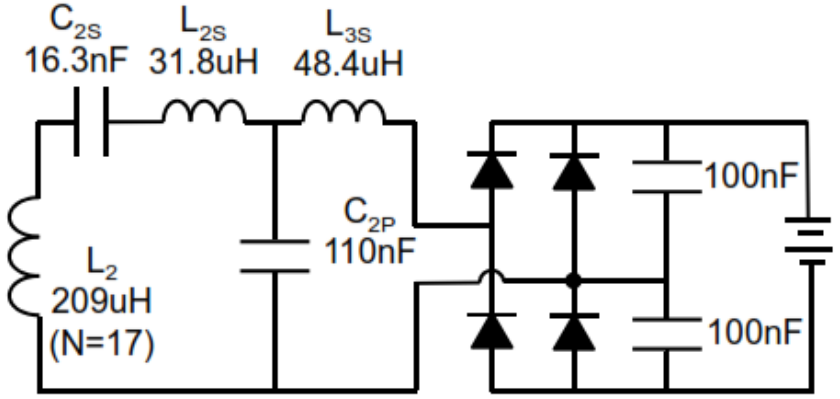


Figure Am2: Mechanical dimensions of the M-VA-WPT1/Z1.

Interoperability:

Standard Coil Specification

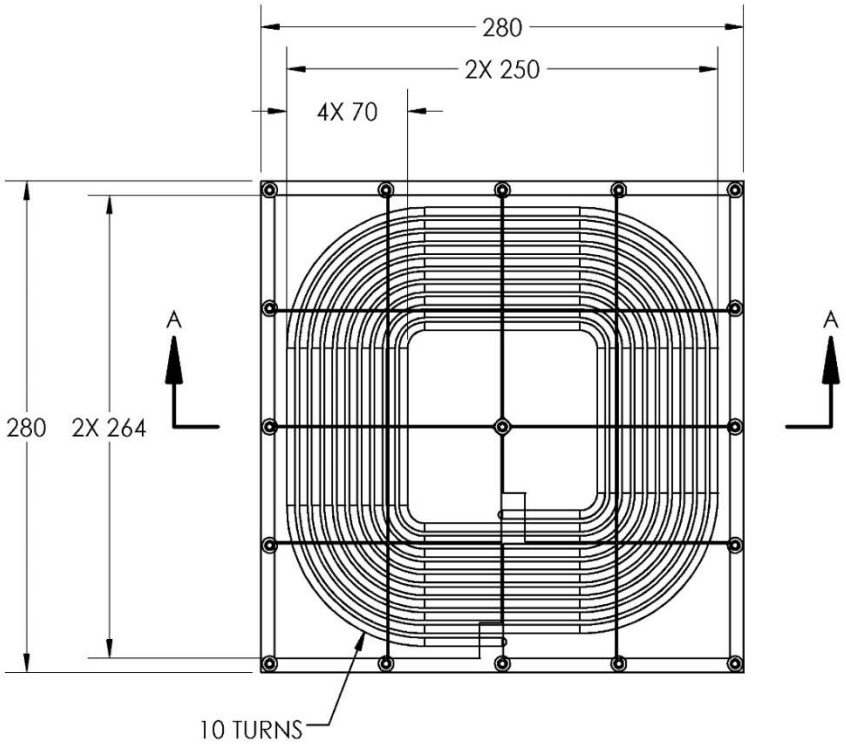
WPT 1 Electrical specification



*Only VA, Z1 Shown

J2954 WPT 2*, Z1-3 Coil Specifications:

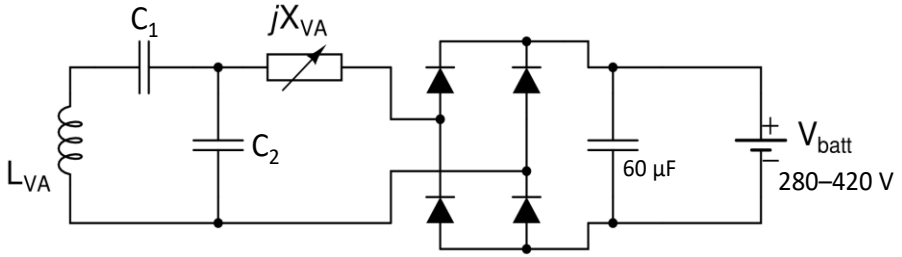
"Reference Coil Set #A: Circular Topology



Interoperability:

Standard Coil Specification

WPT 2A: Electrical specification

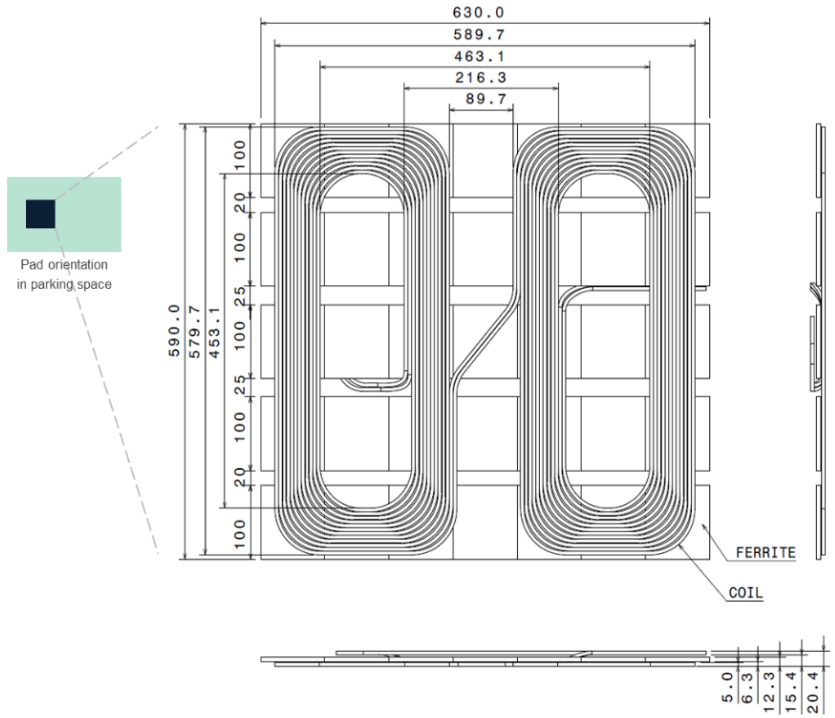


*Only VA, Z1 Shown

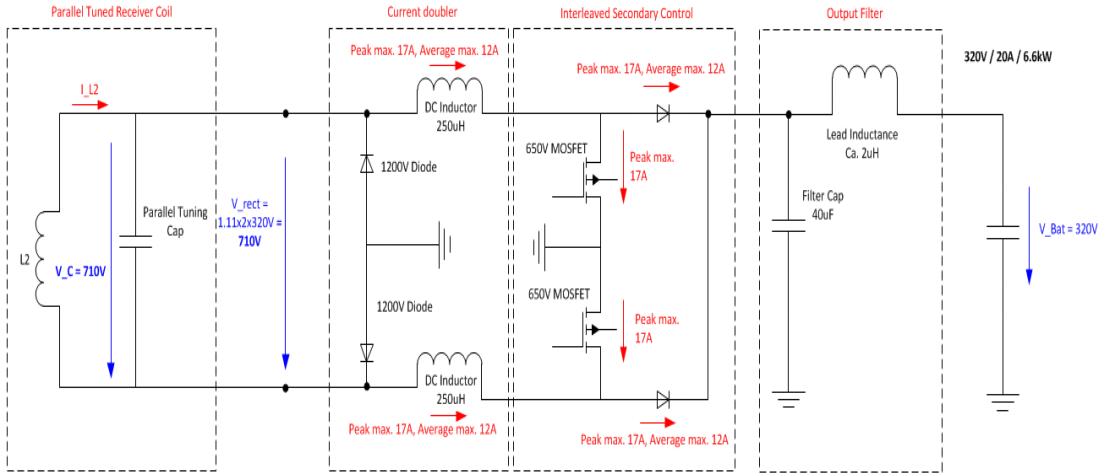
J2954 WPT 2* Coil Specification:

"Reference Coil Set #B: D-D Topology

Interoperability:
Coil
Specification



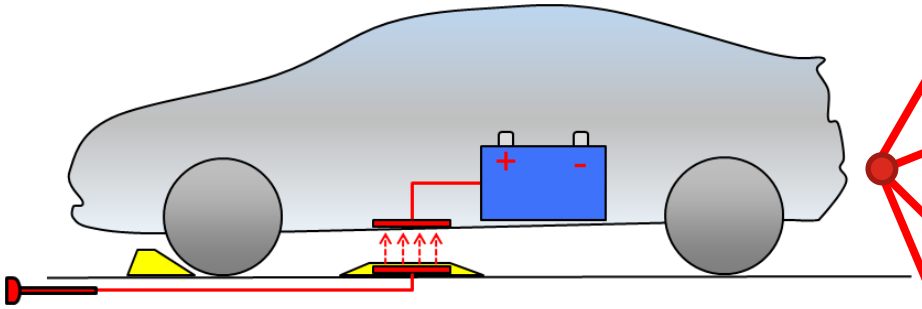
WPT 2B: Electrical specification



*Only VA, Z1 Shown

J2954 Testing Scope

Verification Testing



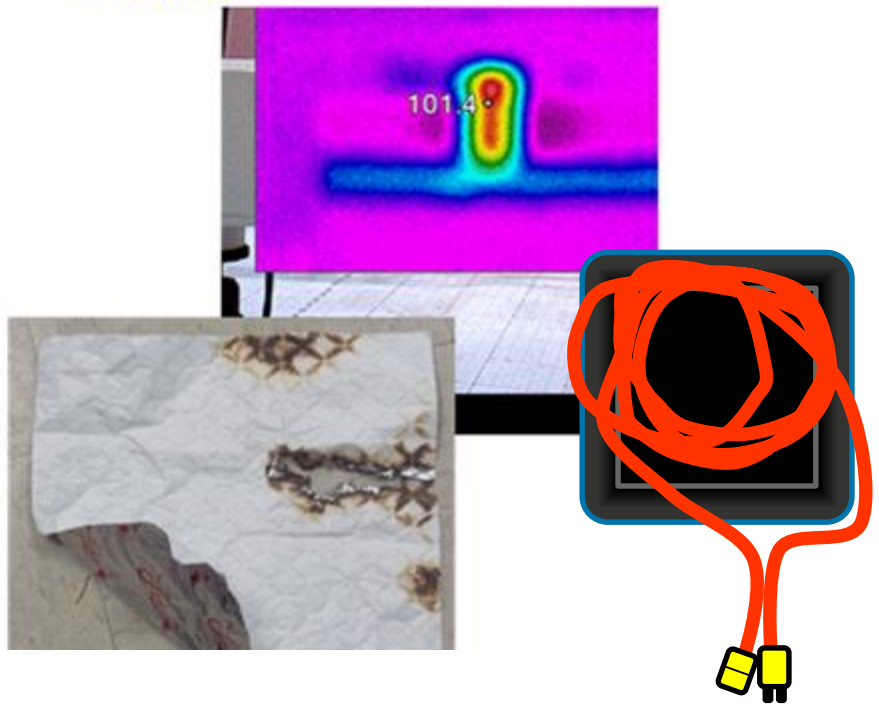
- EM Field
- Performance
- Durability
- Safety

J2954 Safety Limits and Testing

TOPICS FOR J2954

Safety

- Obstacle Detection (Inorganic)
- Magnetic Field ICNIRP
- Communication of Charging Battery SOC Levels, Issues with Temperature, Charging Rate
- Temperature Development Test
- Electric Shock



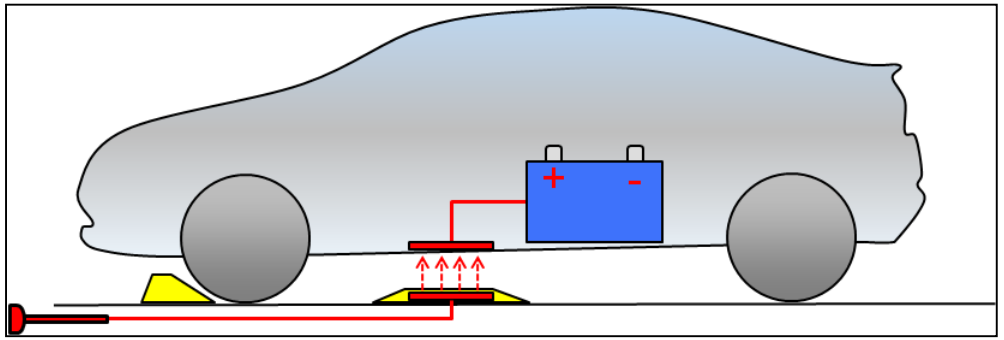
Verification Testing

J2954 Bench and Vehicle Testing

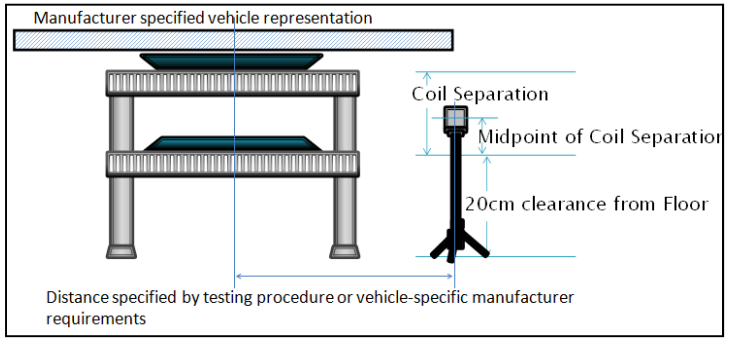
Verification Testing

SAE J2954 Ratings Test

- Test for Matching Coils
  - Design Validation Test – Bench Level
  - Design Validation Test – Vehicle Level
- Test for Mismatched Coils
  - Design Validation Test - Bench Level
  - Design Validation Test – Vehicle Level



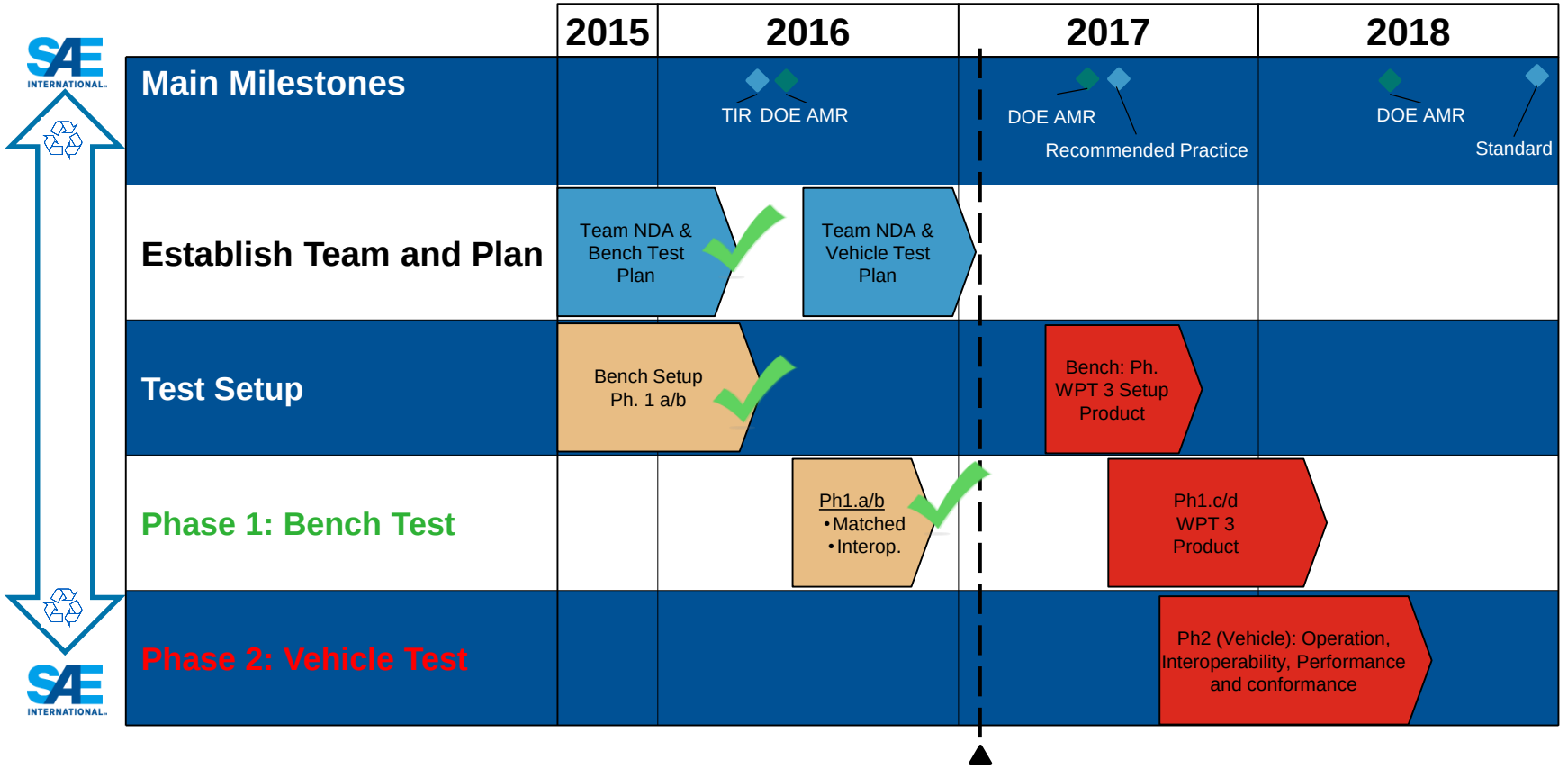
Vehicle Testing



Component Bench Testing

SAE J2954 Testing Project Time Line

Verification Testing:



SAE J2954 “Default” Test Stand at INL

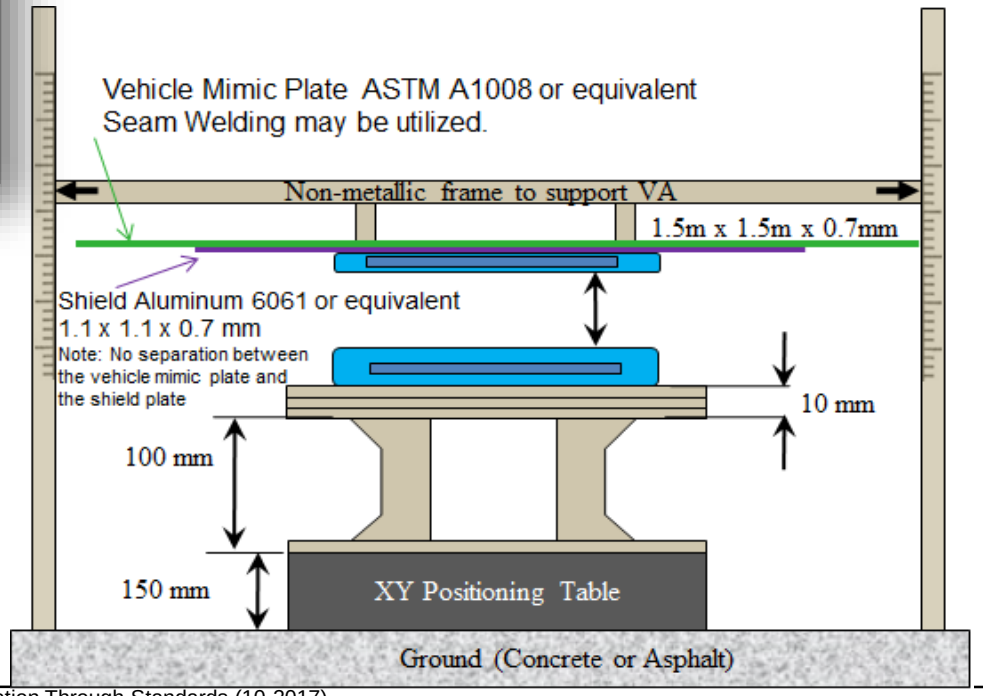
Verification Testing:

Bench Tests

2016-2017

Accomplishments to date:

- Established Baseline for Bench Testing the industry to evaluate WPT
- Confirmed performance, safety and interoperability specification
- Magnetic Interoperability Verification



Testing Summary at Idaho National Lab and TDK in 2016 Test report SAE Beijing on October 2017 (SAE 2017-01-2448)

Key Results Overview INL (through US DOE)

Across all coil misalignments, coil gaps, power levels, and output voltages

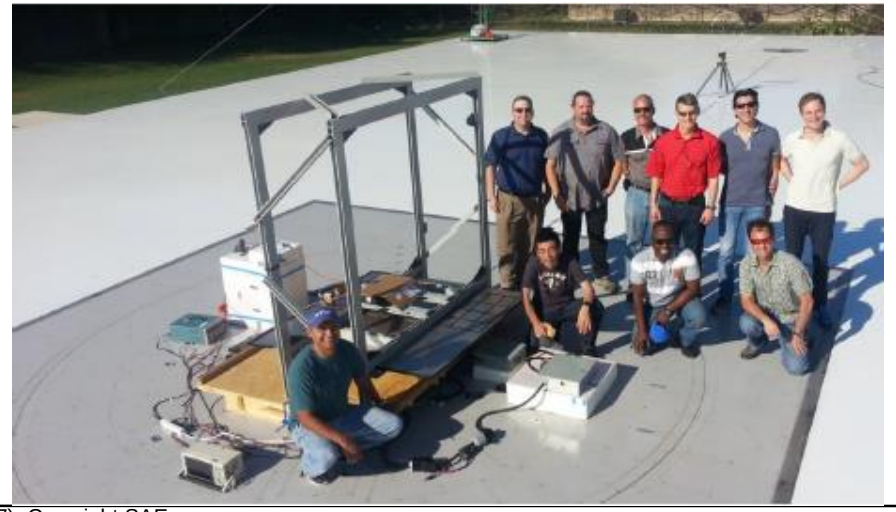
- Nearly all interoperable WPT combination achieved full power transfer to WPT 1 (3.7kW), WPT 2 (7.7kW) with different Topologies (Circular & D-D):
- Matched WPT:
  – System efficiency ranged from 80.3% (Misaligned) to 93.2% (Aligned)
- Interoperable WPT (including different topologies, different power levels WPT 1-2):
  – System efficiency ranged from 79.9% (Misaligned) to 92.4% (Aligned)

Key Results from TDK Testing

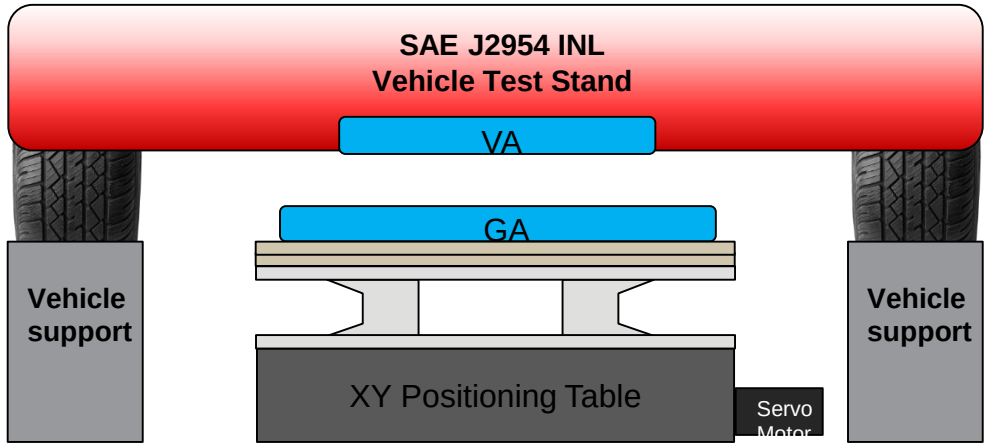
EMF Test Bench Measurements (directional)

WPT 1 – 2.88uT peak

WPT 2 – 4.63uT & 21.49uT peaks



SAE J2954 Vehicle Testing w/ INL & ANL

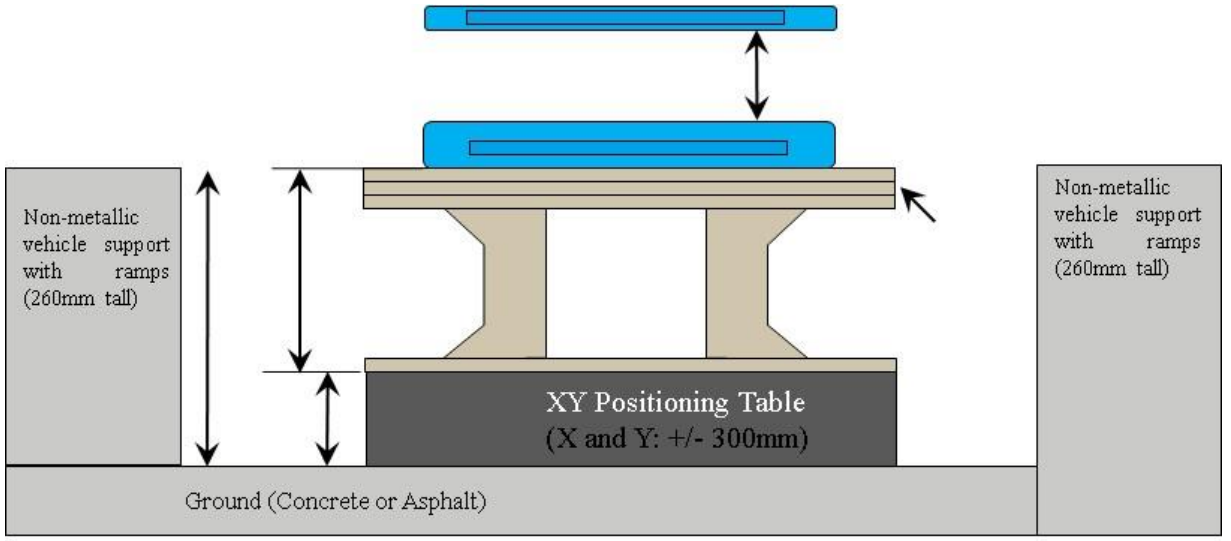


Verification Testing:

Vehicle Tests

2017-2018

- Establish Baseline for Vehicle Testing the industry to evaluate WPT



SAE J2954 Standardization:

- **TIR J2954 (Technical Information Report) Guideline has been released and is available:**
  - Specification for Vehicle and Ground Infrastructure WPT and alignment
  - WPT 1 “Master” Coil Specification Decided (also for standard)
  - WPT 2 “Reference” Coils: Two Coils to be tested, with one chosen in Recommended Practice.
  - Downloadable under: http://standards.sae.org/

- **SAE J2954 Recommended Practice to be published (end of 2017)**
  - Established industry public private partnership for testing of WPT 3 (11kW) systems and vehicles. To generate data to establish both RP & Standard SAE J2954.

- **Idaho National Lab component testing in 2017 and vehicle testing in 2018 at Argonne National Lab**

- **To support commercialization, SAE J2954 Standardization Plan to 2018 enables harmonization for larger scale infrastructure in 2020**

- **H.D. Charging TIR J2954-2 Kicked off (500+kW)**

-THANK YOU-
QUESTIONS?

SAE J2954, WIRELESS POWER TRANSFER

CONTACT FOR QUESTIONS:

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