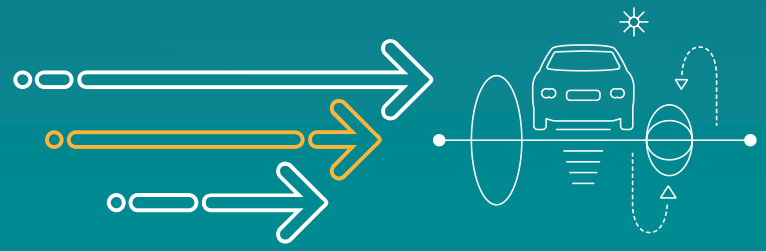
Dr. Grzegorz Ombach, VP Engineering
Qualcomm Europe Inc.
22.09.2015

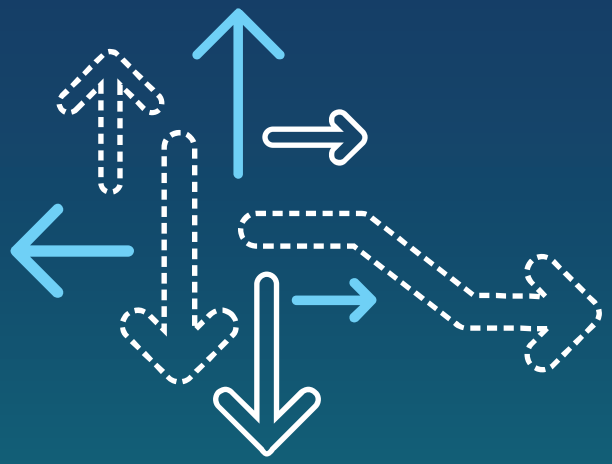
Current status and outlook of stationary and dynamic wireless electric vehicle charging

QUALCOMM HALO™



Agenda

1. Vision for EV Charging
2. Complete System Solution
3. Interoperability Key Factors
4. Conclusions



A Vision for EV Charging - WEVC

Overview of Societal Trends

Global urbanisation

70% of world's population will live in cities by 2050

(World Health Organization 2014)

Infrastructure strain

Total global vehicles increasing from 1.1bn today to 2.5bn by 2050

(OECD Report 2012)

Air pollution

Legislation and fines for pollution

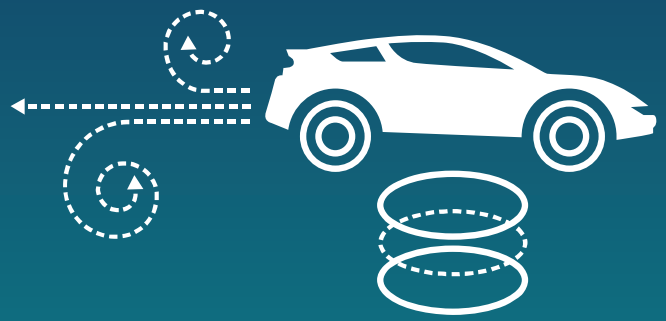
(Environmental Protection Agency – European Commissions)

Health costs

Urban outdoor air pollution is estimated to cause 1.3 million deaths worldwide per year

(World Health Organization)

EVs a Solution but with Barriers to Mass Adoption



Benefits

- Better energy economy
- Non-polluting
- Less noise
- Clean Streets

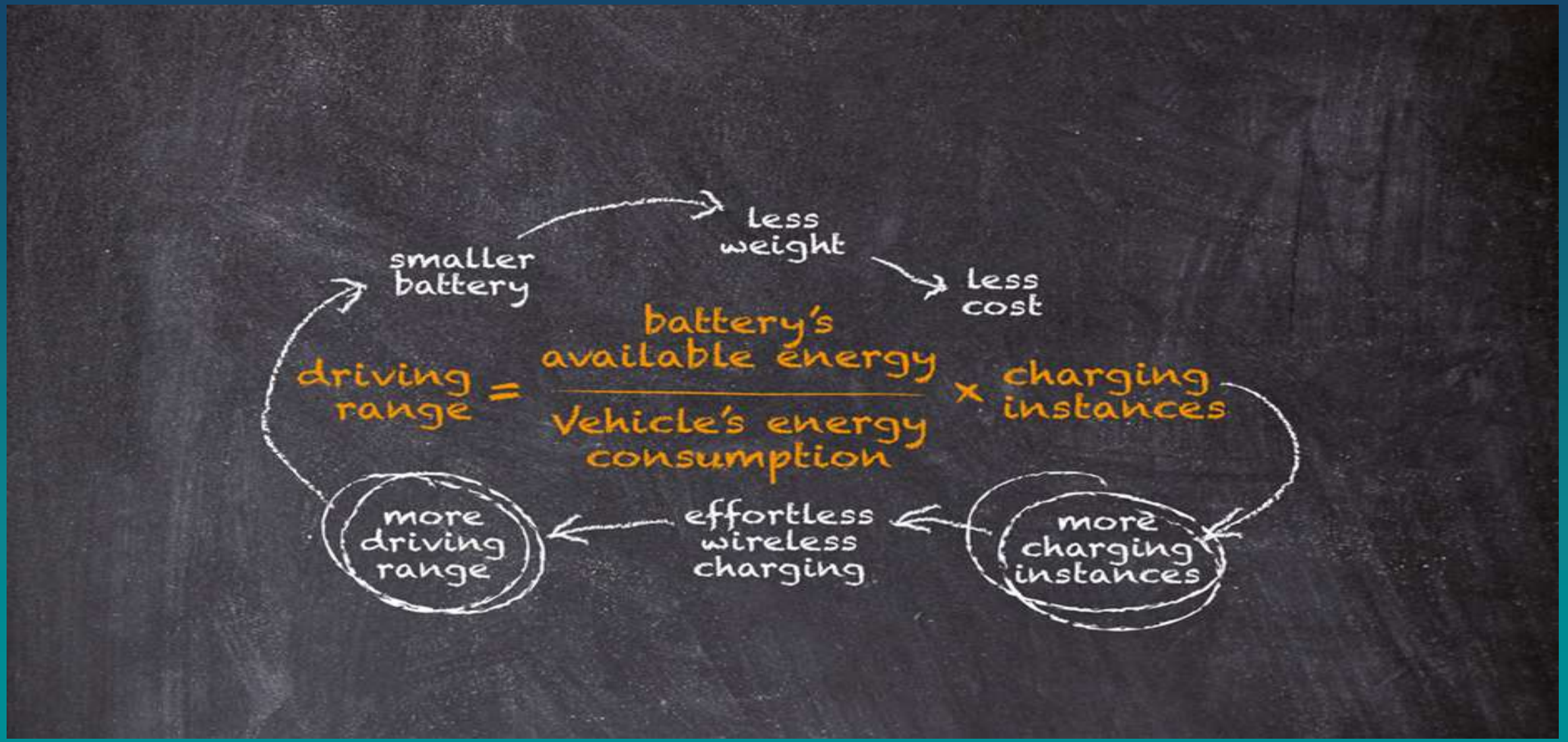
Challenges

- Lack of Standards
- Limited Range
- Time to Charge
- Ease of Charging

Charging Ubiquity

- Infrastructure Lag
- Charging Posts
- Trailing Cables
- Vandalism

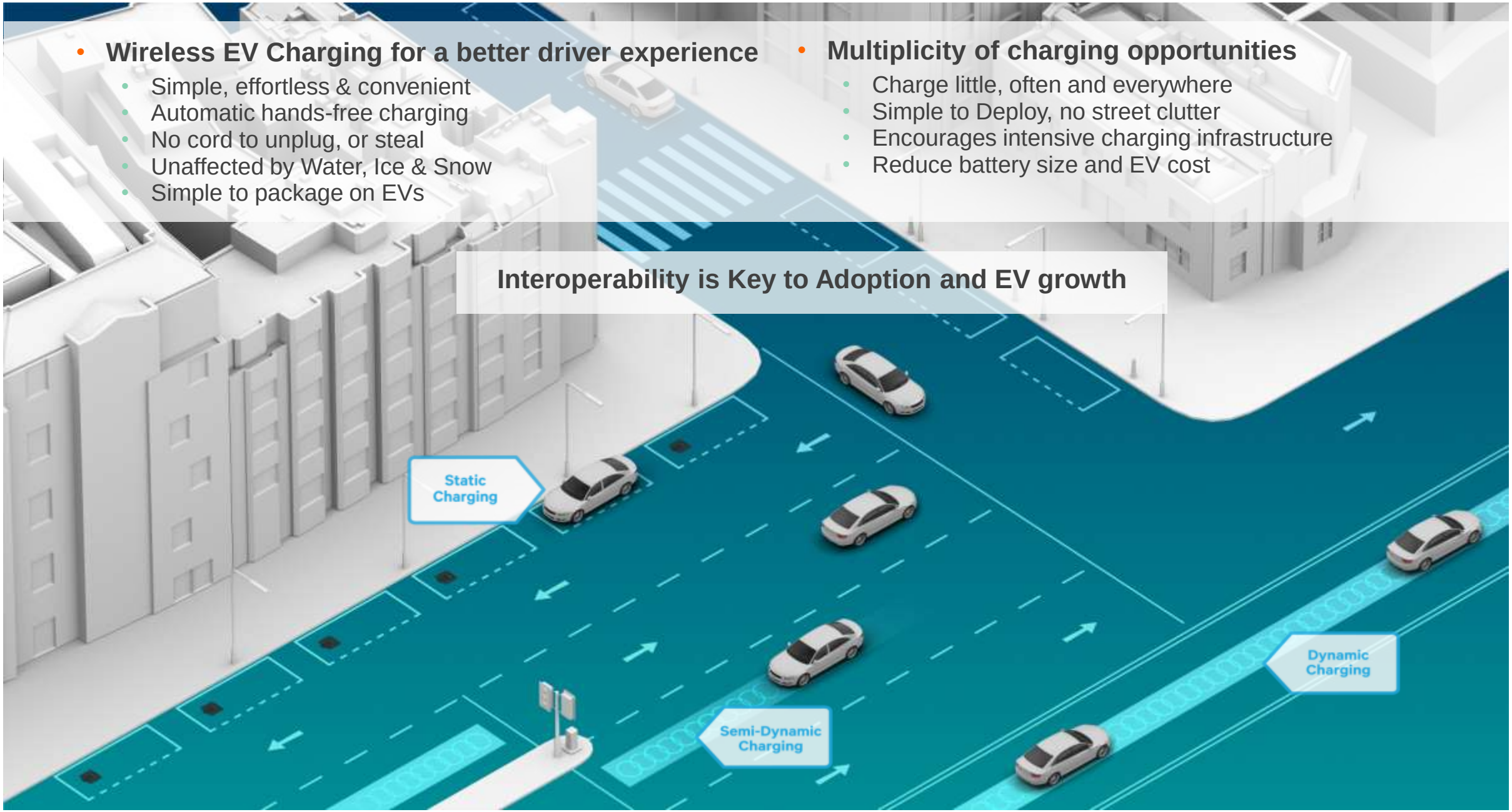
Charging impact on battery size or/and range

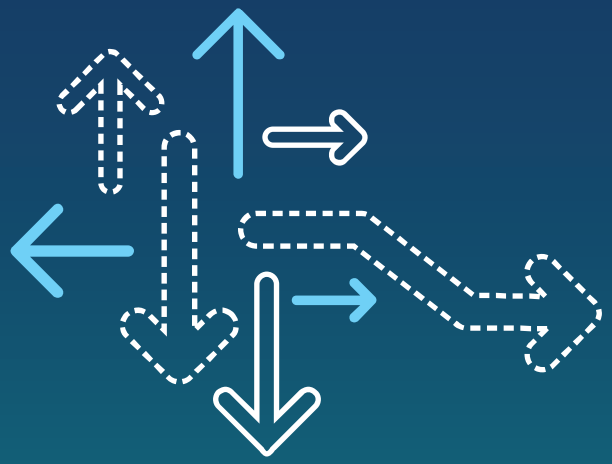


- **Wireless EV Charging for a better driver experience**
  - Simple, effortless & convenient
  - Automatic hands-free charging
  - No cord to unplug, or steal
  - Unaffected by Water, Ice & Snow
  - Simple to package on EVs

- **Multiplicity of charging opportunities**
  - Charge little, often and everywhere
  - Simple to Deploy, no street clutter
  - Encourages intensive charging infrastructure
  - Reduce battery size and EV cost

Interoperability is Key to Adoption and EV growth

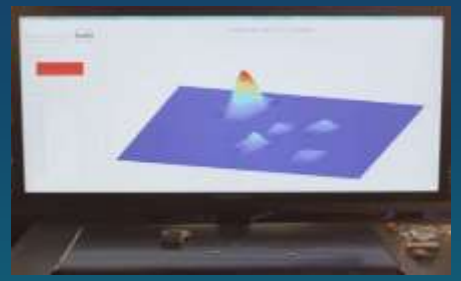




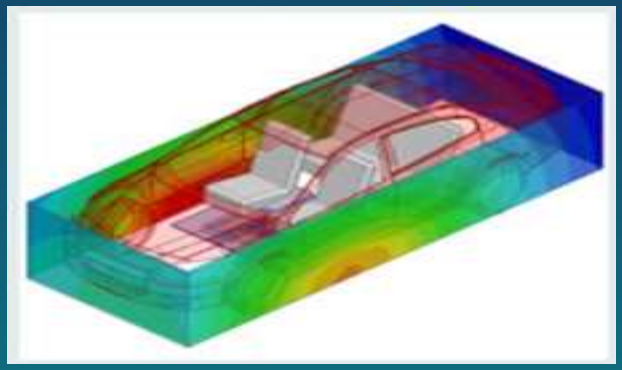
Complete System Solution

Our Complete Solution – All in one

IPT Magnetics&
Power Electronics

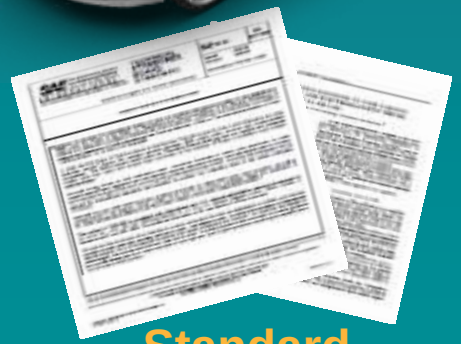


Auxiliary: FOD, LOP,
Positioning



Regulatory Compliance

Application -
System integration



Standard

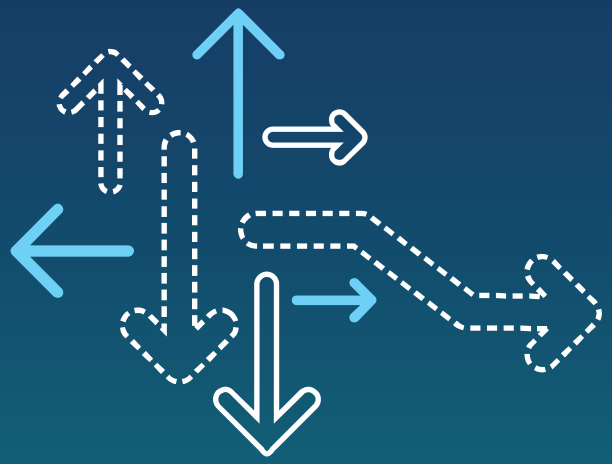
Communication

Power Range

Each system is fully integrated into the vehicle

Output Power	3.7 kW	7.4 kW	20+ kW
Power Input	Single Phase	Single / Three Phase	Three Phase
Base Pad Size	Small - Medium	Medium - Large	Large
Vehicle Pad Size	Small	Small-Medium	Large

Standardization



Standards Overview

ISO (TC22/SC21)
International Standardization Organization
ISO 19363

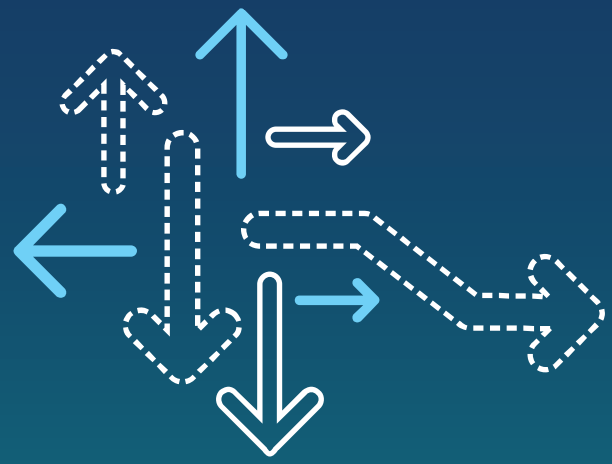
Vehicle Side

Infrastructure Side

IEC (TC69)
International Electrotechnical Commission
IEC 61980

→ Qualcomm are involved in ISO and IEC to cover both the infrastructure and the vehicle standardization

SAE
Society of Automotive Engineers
SAE J2954



Interoperability – Key Factors

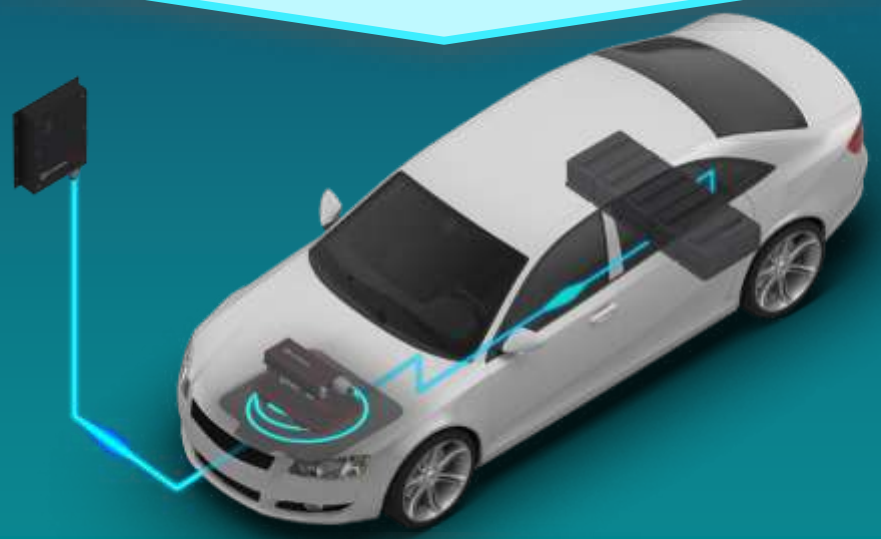
Standardization Areas and Constraints

INTEROPERABILTY REQUIREMENTS–

- Common Operating Frequency
- Magnetic interoperability between vehicle assembly (VA) and ground assembly (GA)
- Vehicle to charger communications
- Default alignment mechanism
- Agreement on VA and GA positioning in parking bay

SAFETY CONSTRAINTS – Thermal and RF

- Foreign Object Detection
- Living Object Protection
- Circuit protection layers
- System control

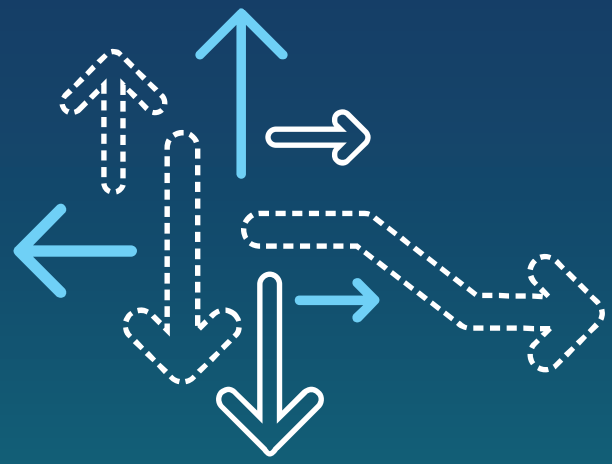


PERFORMANCE

- Power Levels (3.7, 7.4, 22kW)
- Efficiency
- Air gap (absolute and range) [Z1, Z2, Z3}
- Alignment tolerance
- Stationary, Semi-dynamic, Dynamic

COEXISTENCE –
RF and EMC regulations

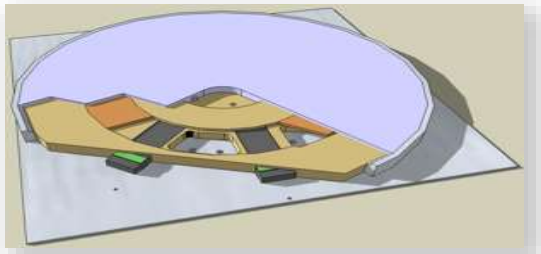
- Vehicle Systems
- Implantable Medical Devices
- Communication Services

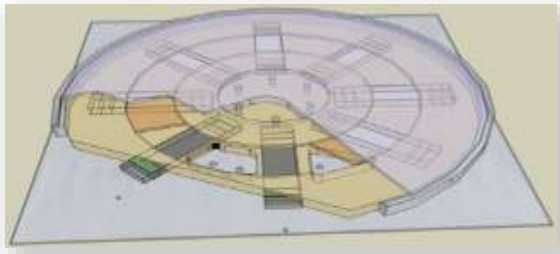


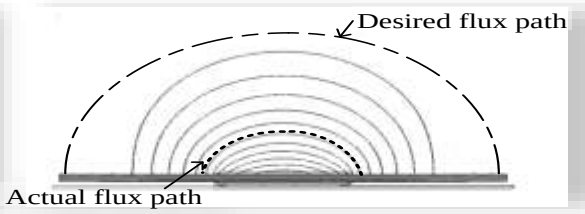
Magnetic Designs

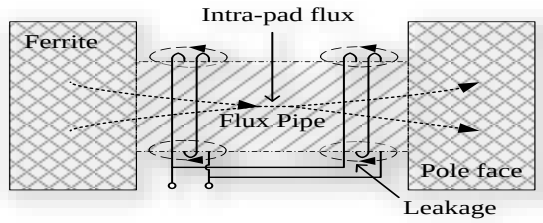
Comparison of Pad Magnetic Architecture

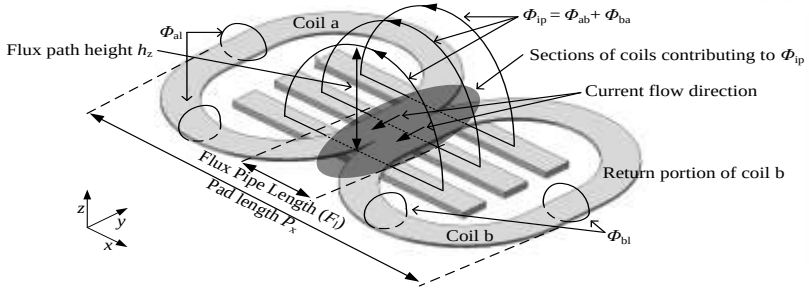
- Circular
  - \+ Low field emissions
  - − Large diameter for z-gap
  - − Low x/y tolerance
- Solenoid
  - − High emissions
  - − Shielding required
- Solenoid
  - \+ Good coupling
  - − High emissions
  - − Shielding required
- Double D / DDQ
  - \+ Low field emissions
  - \+ High Coupling
  - \+ Superior z- gap
  - \+ Superior x/y tolerance

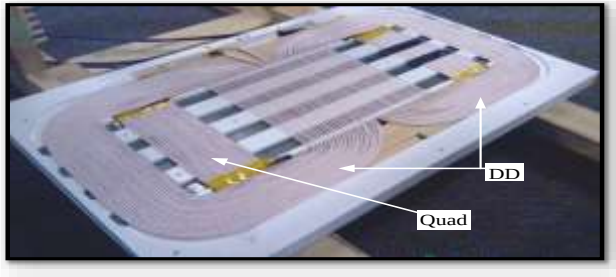




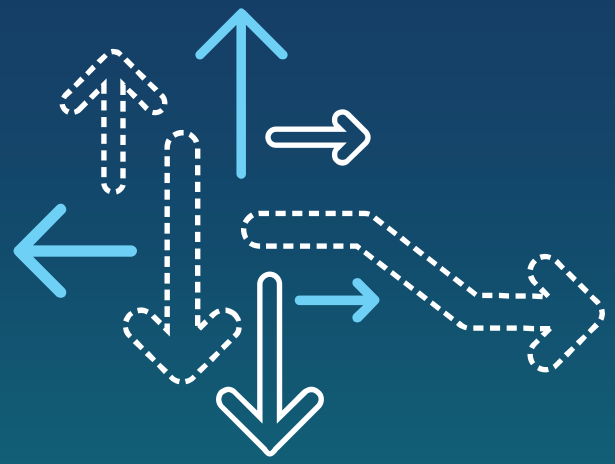








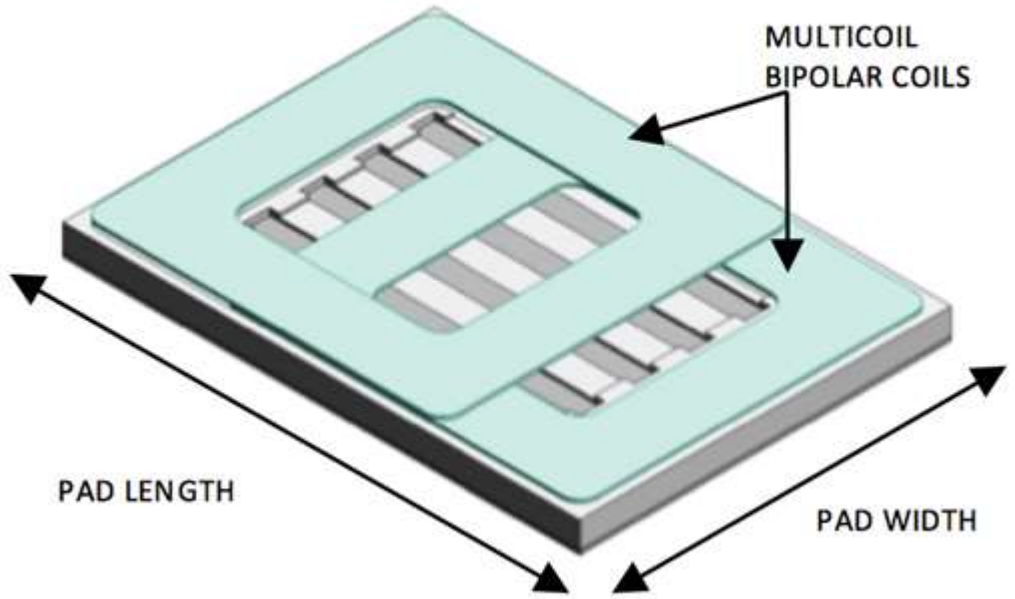
Universal Base Pad



Bi-polar Base Pad - Qualcomm Halo™ WEVC Magnetics

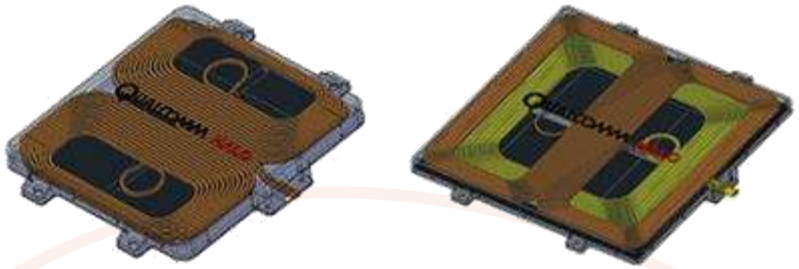
Interoperable with circular/square coil, solenoid and Double D secondary pads

- Low field emissions
- Good coupling
- High coupling
- Superior z- gap range
- Superior x/y tolerance
- Interoperability with single coil pads



Different Magnetic Pad Designs Must be Supported

Circular/Square Coil
Secondary Vehicle Pad



Double D & DD Quadrature
Secondary Vehicle Pads

Single Coil Solenoid
Secondary Vehicle Pad

Bi-Polar Primary Base Pad

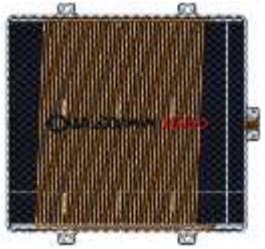
Test Conditions – 3.7 and 7.4 kW Pad Topologies

Vehicle Pad

Circular (CR)

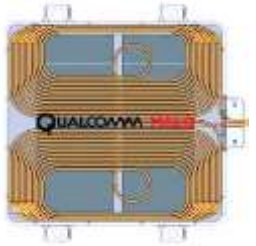
3.7kW@250x250mm
7.4kW@400x400mm

Solenoid (Sol)



3.7kW@250x250mm
7.4kW@400x400mm

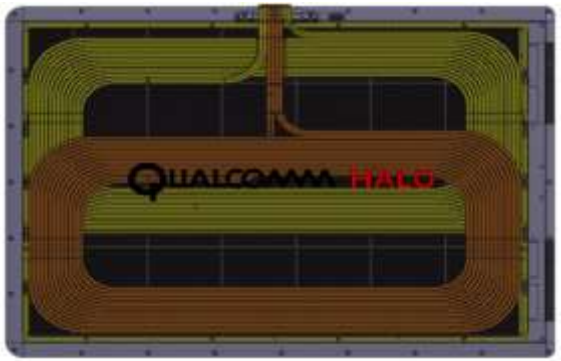
Double D (DD)



3.7kW@250x250mm
7.4kW@400x400mm
7.4kW@340x270mm

Base Pad

Bi-Polar



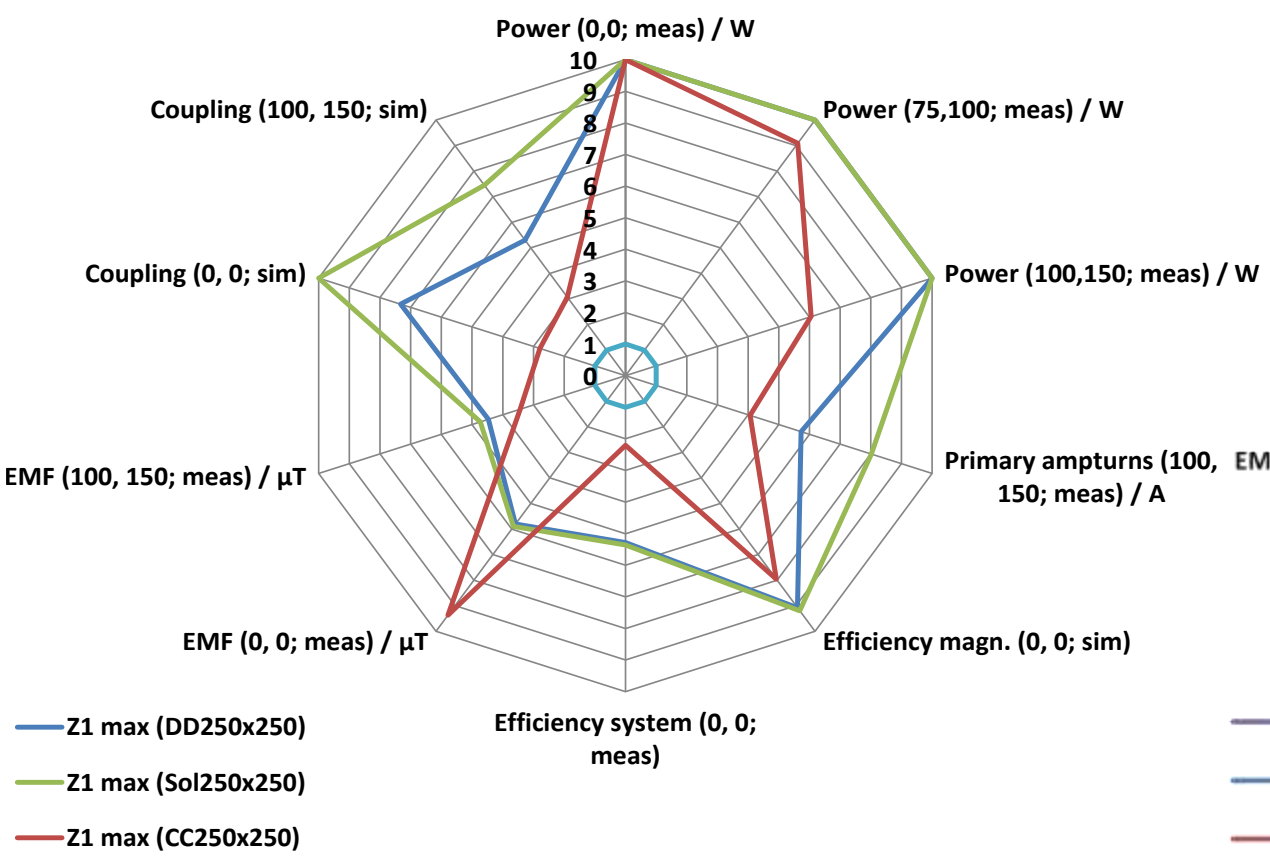
765x575mm

X \ Y	0	50	100	150
0				
50				
75				
100				
150				

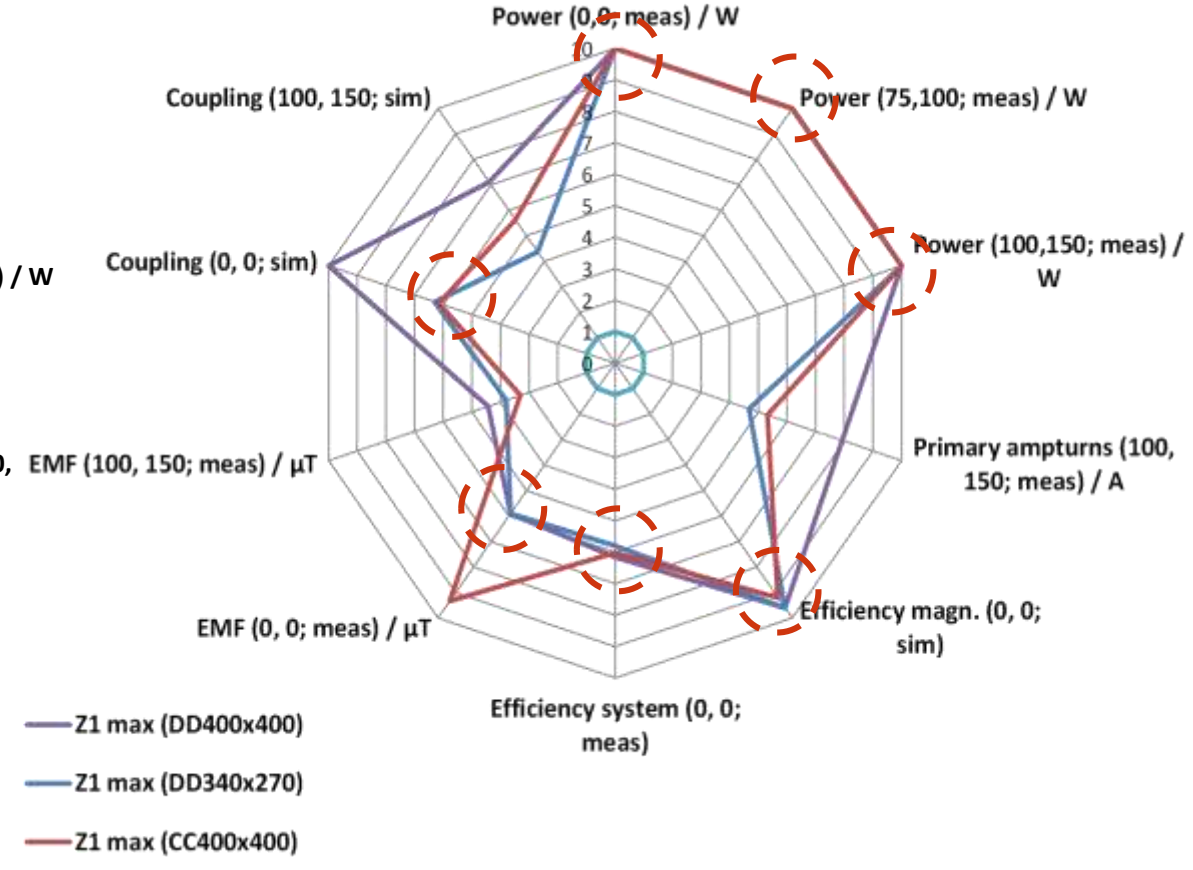
Test Result Summary

40% smaller 7.4 kW Double D Vehicle Pad performs as well as larger Circular Vehicle Pad

3.7kW@Z1max=160mm



7.4kW@Z2min=160mm



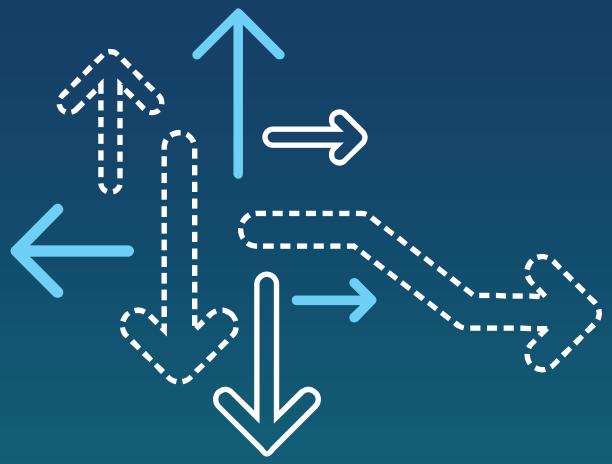
3.7 & 7.4 kW Magnetic Pad Options

About 40% reduction in DD pad size for same performance as Circular pad

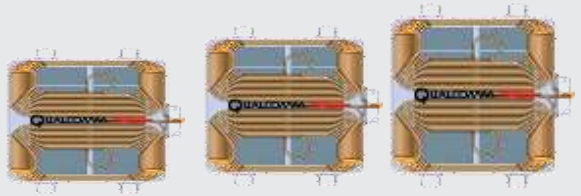
3.7 kW: 250mm x 190mm

7.4 kW: 340mm x 270mm

Semi dynamic and dynamic



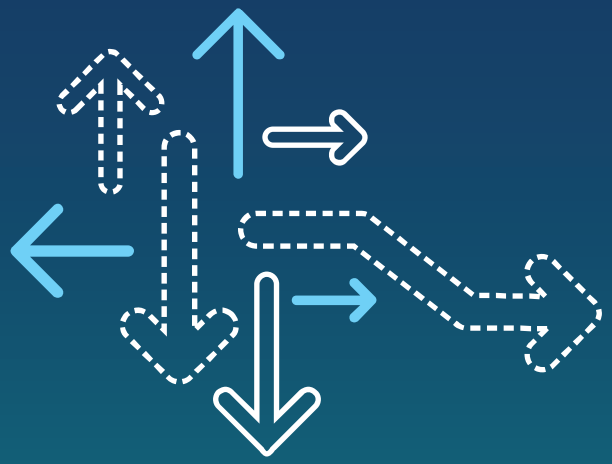
Evolution from Stationary to Semi and Dynamic

	Stationary (*)	Semi&Dynamic (**)
Frequency	85 kHz	85 kHz
Power Classes	**3.7 / 7.4 / 22 kW**	**10/ 20 / 40 / 200 kW**
Offset Tolerance (x/y)	±75 / ±100 mm	Not relevant / ±200 mm
Magnetics (vehicle side)		

(*): Based on worldwide standardization

(**): Proposal for FABRIC project (currently, there are no standards specifying requirements for dynamic charging)

Conclusions



Conclusions

- Bipolar base pad can fulfill requirements as interoperable solution for infrastructure
- Future semi dynamic and dynamic systems should be interoperable with stationary solutions
- The testing demonstrated that a single universal primary base pad could effectively transfer power to different kinds of secondary vehicle pads, different power levels and different Z heights.
- It was possible to reduce the Double D Vehicle Pad size by more than 40% and still reach better performance than the Circular VP

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Driving adoption of new technologies for EVs: Qualcomm HALO WEVC

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Thank you

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