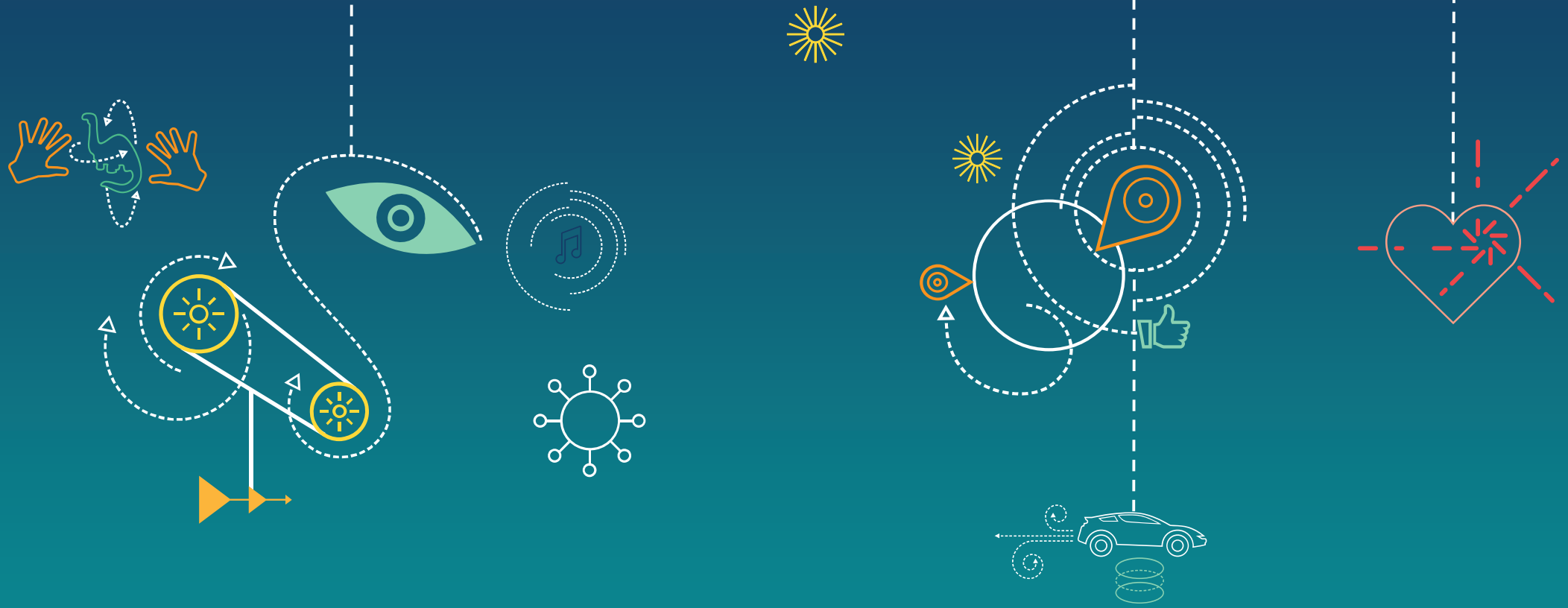
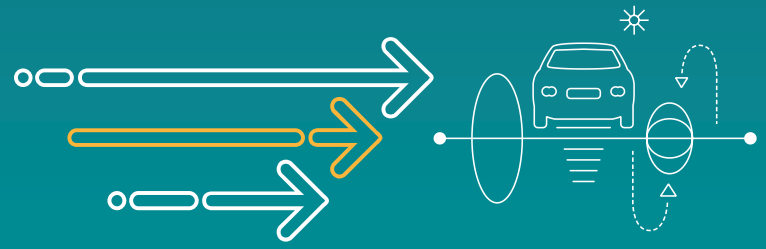


Qualcomm Technologies, Inc.

Dr. Chris Borroni-Bird
VP, Strategic Development, Qualcomm
IBA Conference - session on Electromobility,
September 22, 2016

Wireless EV Charging

QUALCOMM HALO™

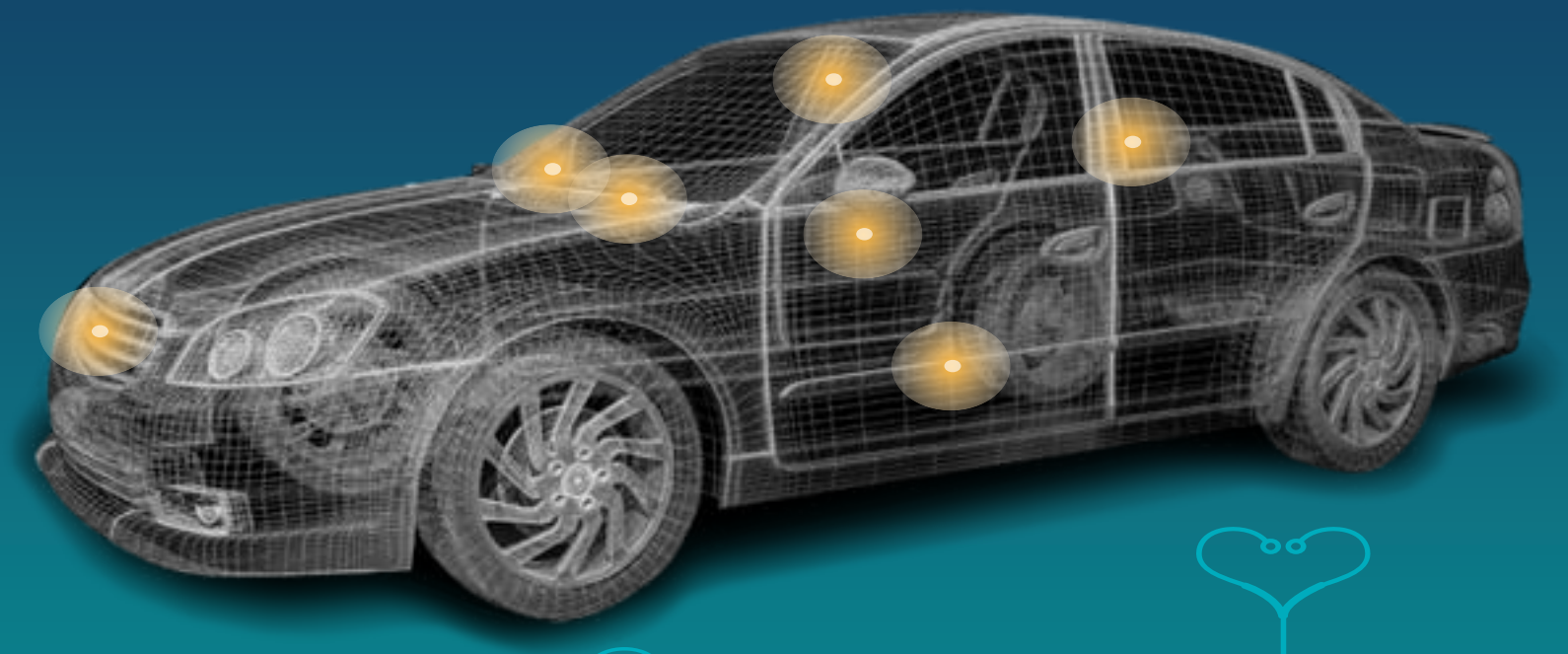





BORN MOBILE



The Future of Urban Mobility is Autonomous, Connected, Electric and Wireless – as multiple technologies intersect automotive



Entertainment

Gesture

Location

Safety and Security

Peer to Peer

Health Monitoring

Augmented Reality

ADAS

Wireless Charging

Cloud content

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 Commission)

Health costs

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

(World Health Organization)

Air pollution costs Europe ~ $2.5T per annum in early deaths and disease, according to The World Health Organisation!

Costs of polluted, dirty air are equivalent to one tenth of Europe's GDP

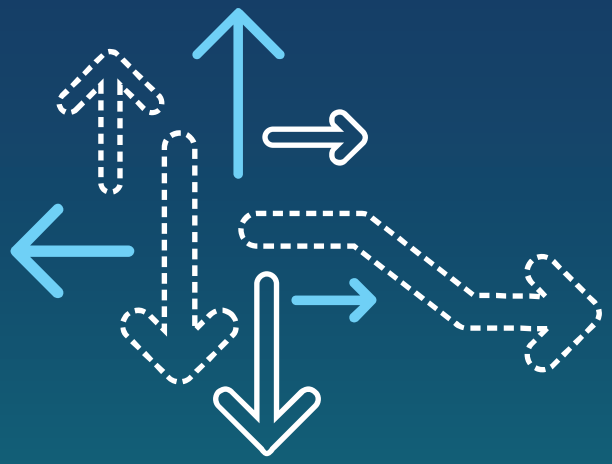
Germany, UK and Italy among the hardest hit economically

Wireless Charging (WEVC) Improves User Experience

WEVC is a key attribute for a more user-friendly EV

- **Seamless user experience for charging**
- **Enables more convenient charging even for short periods, reducing range anxiety**
- **Qualcomm Halo is working with key OEMs to implement WEVC across multiple platforms**

- **Simple, effortless & convenient**
- **Automatic hands-free charging**
- **No cord to unplug, tangle or foul**
- **Unaffected by water, ice & snow**
- **Simple to package on EVs**



Qualcomm Halo™ Technology

QUALCOMM HALO™

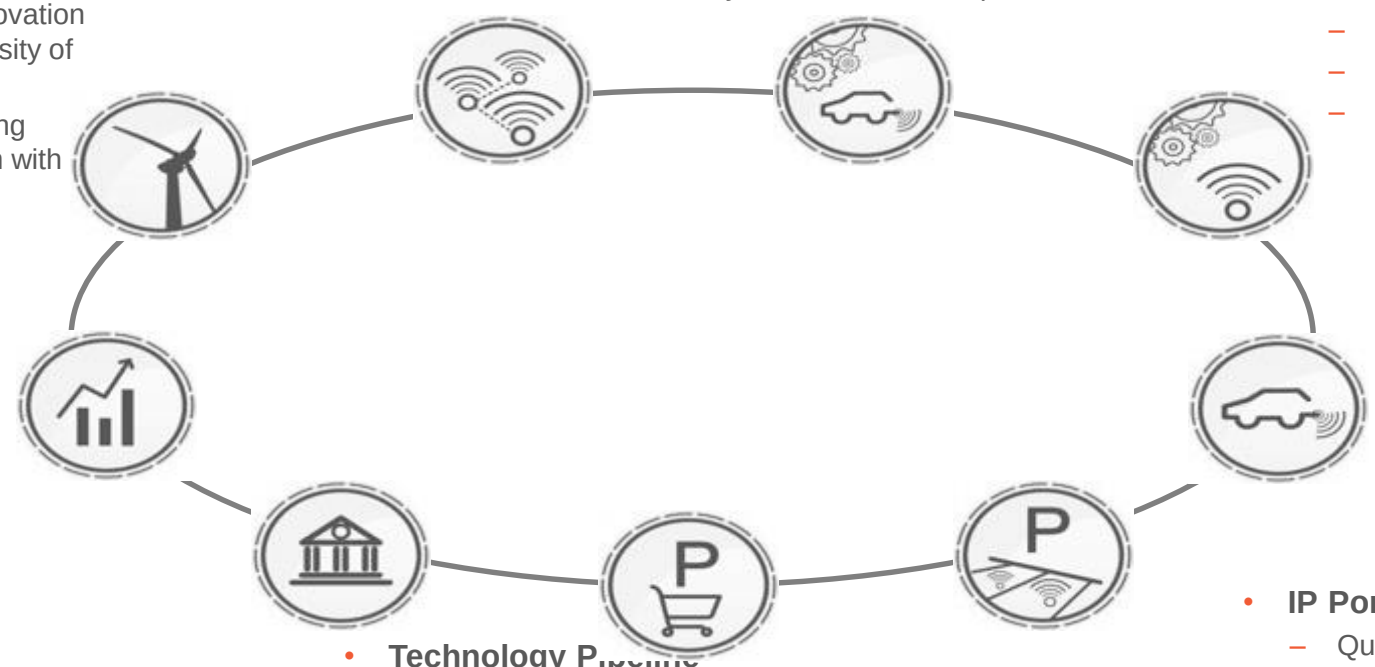
For nearly 30 years, the automotive industry has trusted Qualcomm to deliver innovative automotive solutions

- **Legacy in Automotive**
  - 25 years of automotive innovation
  - Delivering innovative future-proof solutions
  - 20 year Heritage of WEVC innovation in collaboration with the University of Auckland
  - Delivering advanced engineering WEVC projects in collaboration with global OEMs

- **Standards**
  - Active involvement in development and drafting of standards in SAE, CISPR, ISO et al

- **Regulatory**
  - In-house expertise
  - Test and H-field leakage assessment
  - Simulation methodologies
  - Safety systems including Living object protection and foreign object detection

- **Backed up by 20 Years' WEVC R&D and Engineering Collaboration with University of Auckland**
  - World leadership in wireless power for EV and industrial applications
  - World leaders in magnetic design solutions
  - Excellence and novelty in electronics and power electronics



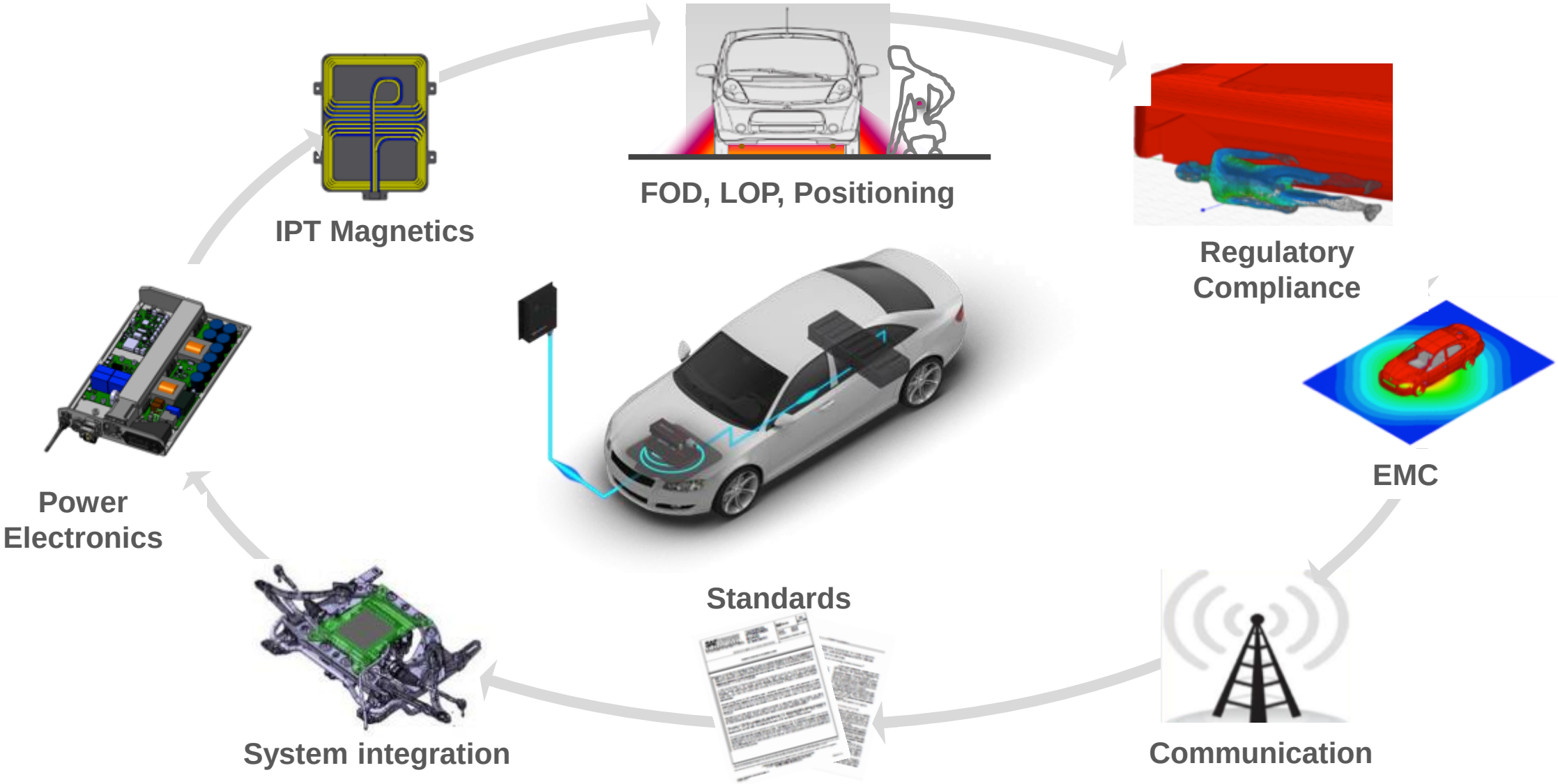
- **Technology P.[illegible]**
  - Advanced technology roadmap for core system and ancillaries
  - Focus on cost and package optimisation; higher power; interoperability and co-existence
  - Dynamic and semi-dynamic systems
  - Functional Prototypes and reference designs

- **Unrivalled R&D and Engineering Teams**
  - Three engineering centers (Munich, New Zealand and Switzerland)
  - Advanced magnetics design
  - Power electronics design, test and prototype
  - Dynamic and Semi-dynamic R&D
  - High Power System Design & Prototyping
  - Ancillaries, safety systems and co-existence

- **Technology Transfer**
  - Supports Licensees to gain an understanding of Qualcomm Halo™ technology
  - Become familiar with a specific Qualcomm Halo™ Wireless Electric Vehicle Charging (WEVC) implementation
  - Start knowledge transfer process to enable future designs of bespoke WEVC systems

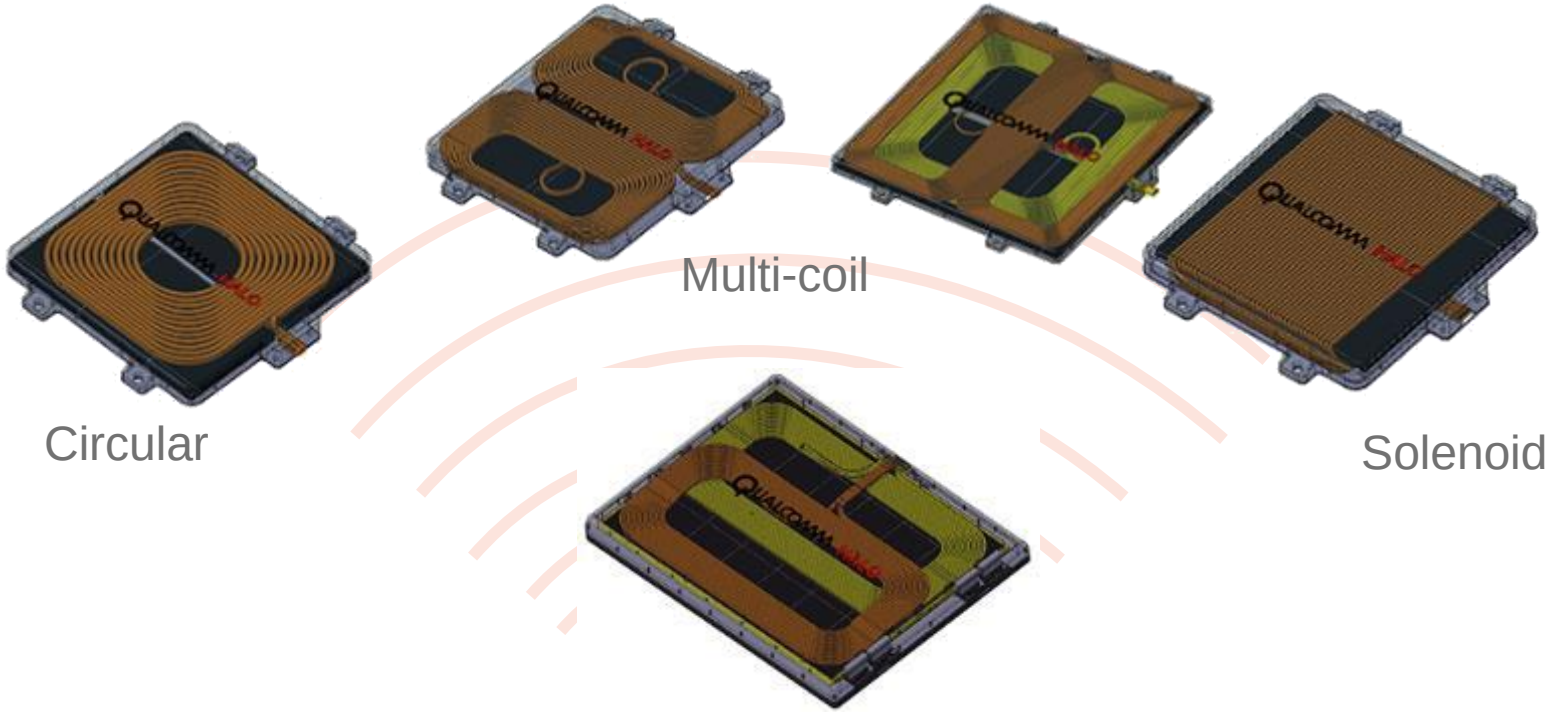
- **IP Portfolio**
  - Qualcomm has a broad and deep WEVC patent portfolio that applies to various solutions to address real world technical issues
  - The broad spectrum of technologies covered by Qualcomm Halo™ Patents includes solutions to problems related to – among other things – coupling factor, coupling factor variability, system operation, FOD, LOP, alignment, and communications

Qualcomm Halo – delivering end-to-end WEVC technology



Advanced magnetics deliver greater X, Y & Z tolerance, higher power, efficiency, smaller package & interoperability

From single coil to multi-coil magnetic designs



Interoperability across multiple vehicle pads delivered through the use of a single Multi-coil base pad topology

Evolution of Qualcomm Halo; Multiple System Integrations

2010 | 2011 | 2012 | 2013 | 2014 | 2015

3kW Citroen C1

7kW Rolls Royce

3kW Citroen C1 Upgrade

3kW Mitsubishi i-MiEV

20kW Drayson

Rolls Royce @ CES

3kW Delta E4

3kW Renault Fluence

7kW Renault ZOE

3kW Honda Accord

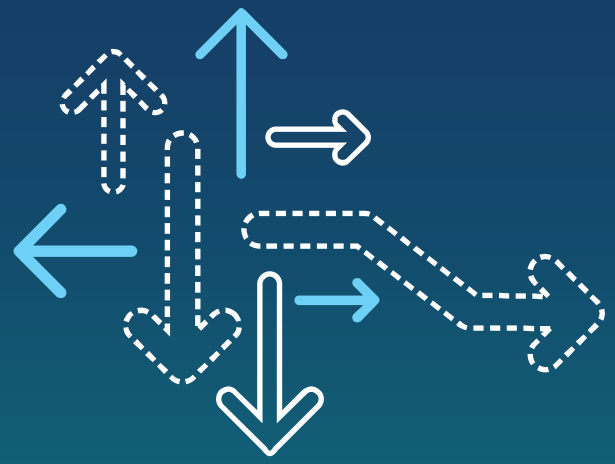
7kW Nissan Leaf

3kW BMW i3 + i8

7kW BMW i3

7kW BMW i8

3-20kW Formula E Fleet



Qualcomm – Business Model Advantages

QUALCOMM HALO™

Qualcomm Halo Horizontal Business Model

A Collaborative Approach with Automotive Industry

- Fundamental R&D
- Reference Designs
- Standards & Regulatory

- Convert system designs to complete products
- Enhance & differentiate designs

- Set product specifications
- Integrate systems into cars

Horizontal business model allows aggregation of R&D spend & technology transfer to suppliers

Licence business model benefits industry, creates a global supplier network

- Advanced WEVC technology accelerates time-to-market
- System design approach delivers a customisable technology solution – can be tailored to each OEM's requirements - while maintaining a "technology platform" approach to maximise economies of scale
- Ongoing co-development with automotive OEMs and Tier 1s ensures fit-for-purpose, relevant technology
- Extensive engineering collaboration for system design, testing & simulation, & vehicle integration
- Peer review of designs & systems
- Advanced Roadmap delivers sequential product improvements supporting standardized & interoperable technology suitable for stationary & eventually dynamic charging
- The business model is built to deliver mutual success – royalty payment based on technology sales
- Non exclusive approach, licensing rather than manufacturing, to drive competition & support market entry to develop the wireless ecosystem

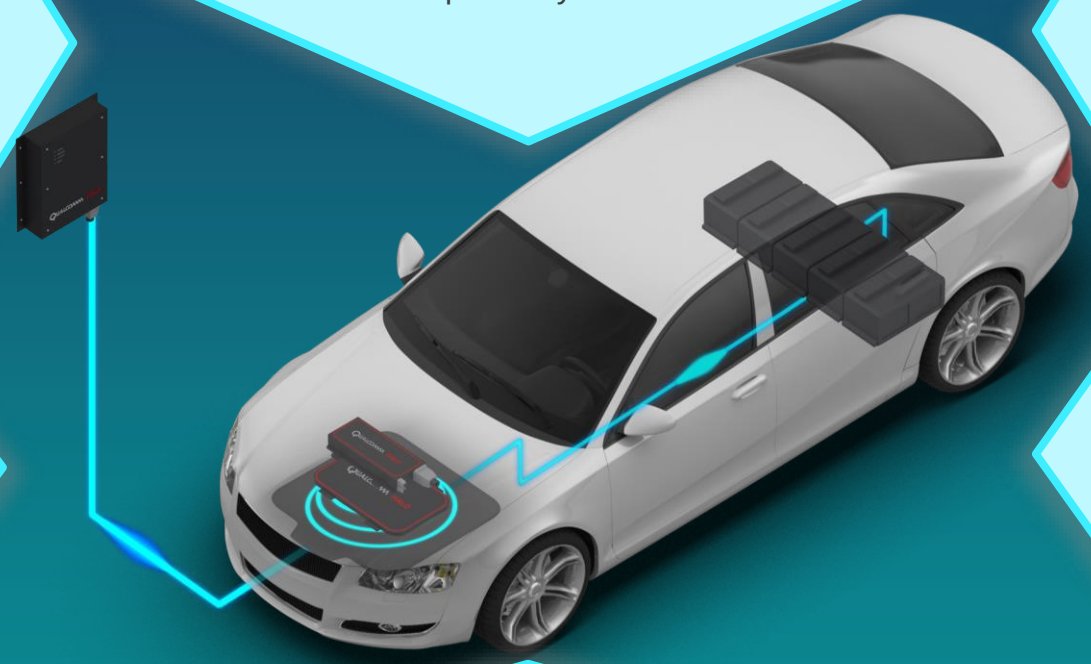
A complete solution

BUSINESS MODEL –
License multiple suppliers
- Unmatched Investments in Innovation
- Build healthy Supplier network
- Foster competition – reduce cost
- Surety of supply
- Engineering support
- Comprehensive IP portfolio
- Charging Operators / Automakers

SAFETY –
Thermal and RF
- Foreign Object Detection
- Living Object Protection
- Circuit protection layers
- Primary/secondary control

COEXISTENCE –
Non-Interfere EMC
- LCL design
- Vehicle Systems
- Implantable Medical Devices
- Communications

STANDARDS–
- Influence SAE/CISPR/ISO
- 85kHz ✓
- Interoperability ←



COMPLIANCE –
RF Regulations
- In-house expertise
- Simulation methodologies
- At 3, 7, 11 & 20kW Power Transfer
- At tolerance X/Y and Z to 250mm

PACKAGING / INTEGRATION
Cross-platform Future Proof
- Parallel tuned current source
- For multiple vehicle platforms
- Increasing power 7kW / 11kW
- Cross Company/Platform suitability
- Demonstrated integration CAN

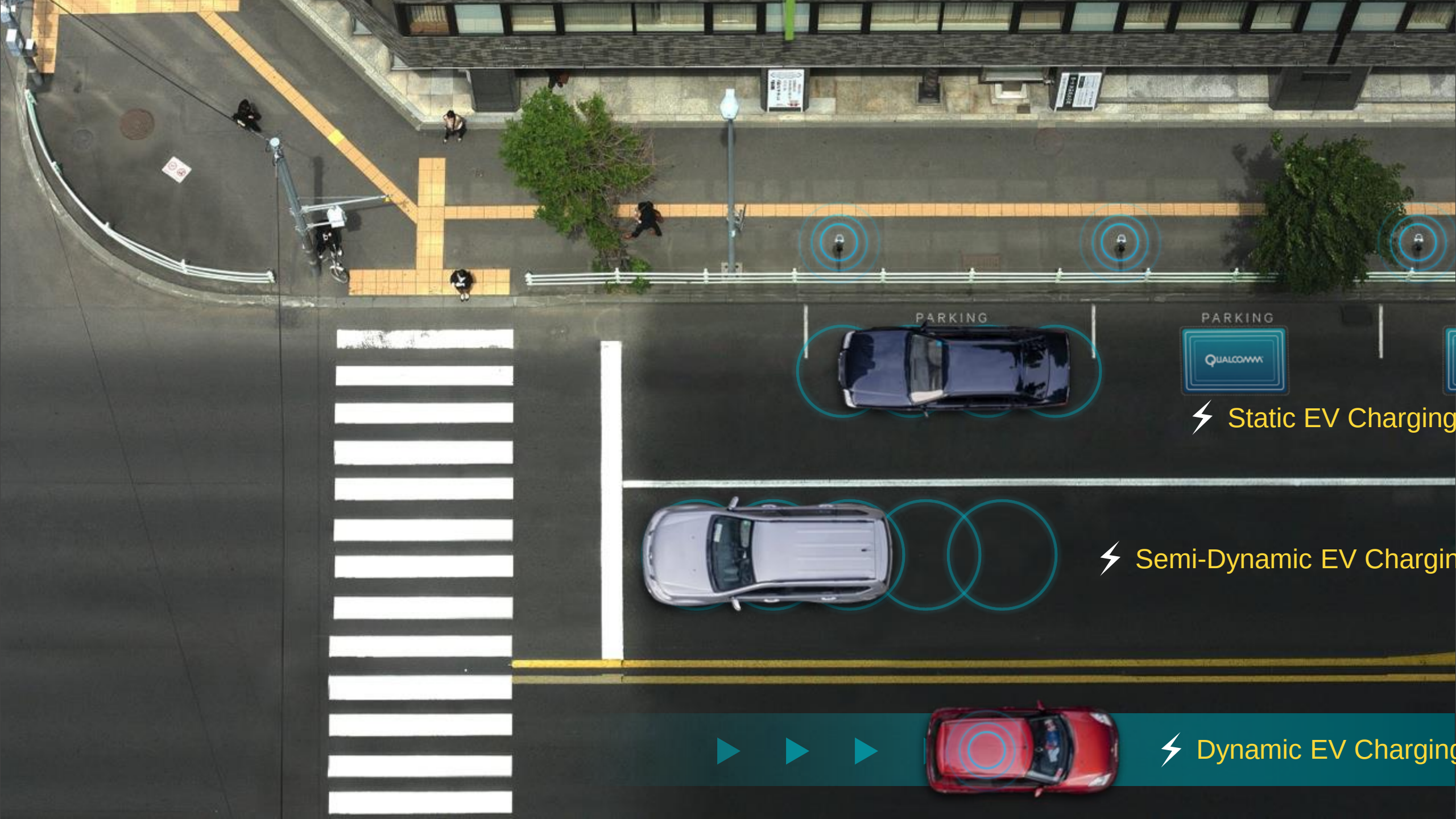
PERFORMANCE /& ROADMAP
Power, Vehicle Types, Mode
- 3.6kW, 7.2kW, 11kW & 20kW
- Primary/secondary control
- Car, Van, Taxis, SUV
- Interoperability
- High efficiency >90%
- Stationary, Semi-dynamic, Dynamic

EASE OF USE –
Tolerant to Misalignment (X/Y)
- Ease of parking
- Alignment feedback
- Enables Autonomous vehicles
- High Z = flush vs. buried deploy
- Maintaining compliance to RF regs

Qualcomm® technologies and Formula E

Wireless charging with Qualcomm Halo™ technology

- Enhancing the fan experience
- Driving adoption of new technologies for EVs


PARKING
PARKING
QUALCOMM
Static EV Charging
Semi-Dynamic EV Chargin
Dynamic EV Charging

Thank you

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