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Feasibility analysis and development of on-road charging solutions for future electric vehicles

Operational requirements for dynamic wireless power transfer systems for electric vehicles

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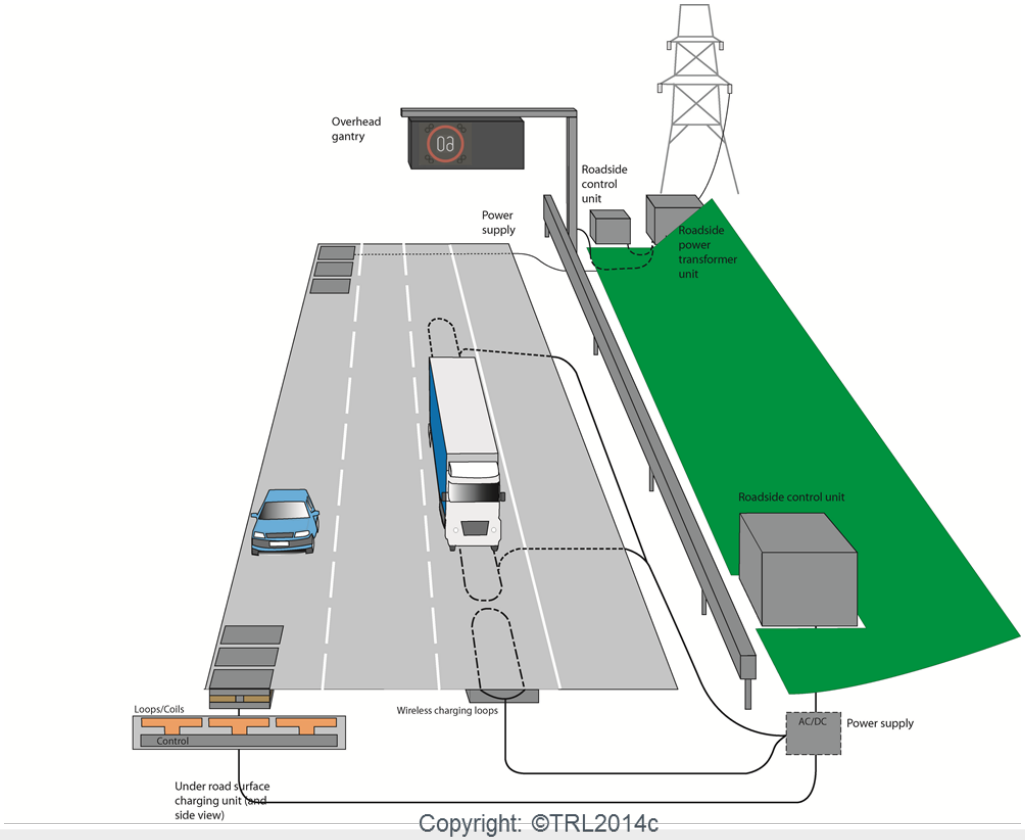
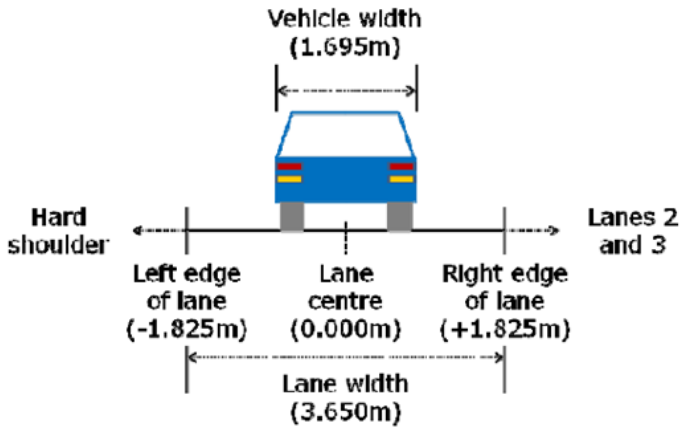
Agenda

1. Misalignment tolerance
2. Power transfer lane segmentation
3. Grid integration



Requirements for misalignment tolerance

1. Methodology:
   - Use of TRL's DigiCar Driving Simulator
   - Data obtained from a scenario where a participants followed a lead vehicle on an otherwise empty motorway
   - Lead vehicle speed varied between 70km/h and 110km/h sinusoidally over a period of 20 seconds
   - Length of car-following section was 13km
   - Lane dimensions are shown



Requirements for misalignment tolerance

1. In total, 36 drives were complete
2. Aged between 25 and 45 years old (mean age: 31.1 years; SD: 6.69 years)

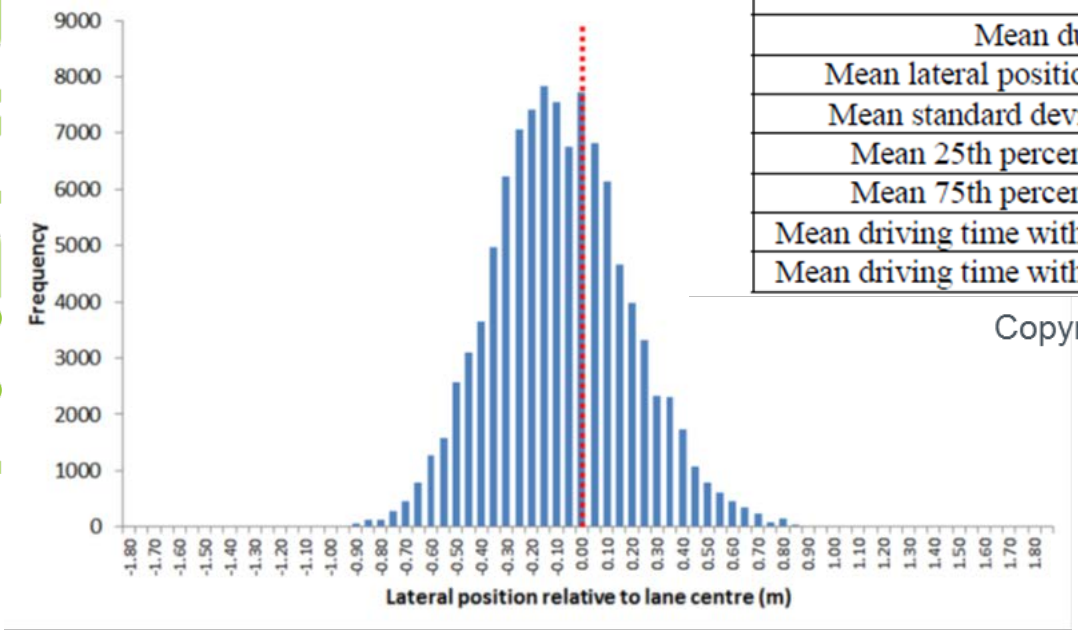
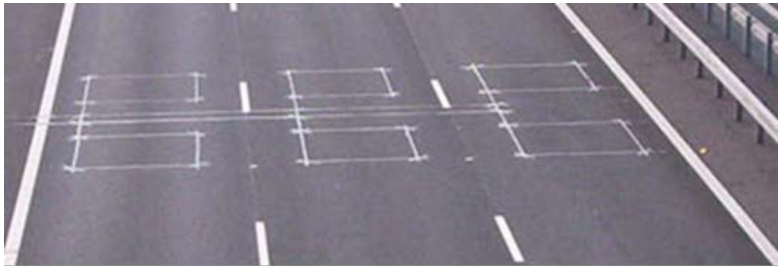


Table 1: Summary of the analysis of lateral position

Measure	Value
N	36
Mean duration (seconds)	145.3
Mean lateral position relative to lane centre (m)	-0.108
Mean standard deviation of lateral position (m)	0.181
Mean 25th percentile of lateral position (m)	-0.230
Mean 75th percentile of lateral position (m)	0.020
Mean driving time within ±0.05m from lane centre (%)	13.9
Mean driving time within ±0.15m from lane centre (%)	37.9

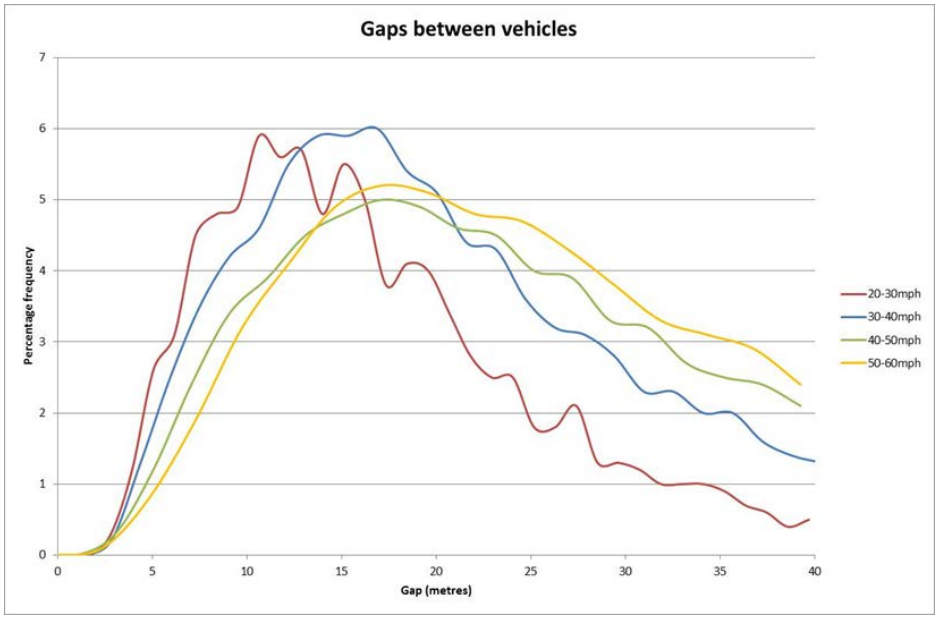
Power transfer section segmentation and separation requirements – impacts on road network performance

1. Methodology:
   - Data was analyzed from MIDAS traffic loops installed in the UK
   - MIDAS loops are configured in pairs to enable them to measure speed and vehicle length.
   - Total length of the loop array is 6.5m.



Power transfer section segmentation and separation requirements – impacts on road network performance

1. Results:
   - Most common time headway on busy motorways is 1.1seconds, equivalent at 80.5km/h to a gap between vehicles of 20m.
   - In motorway queues with stop-start driving, vehicles typically occupy 10m each, this equates to a 4m gap between vehicles on average
   - 1% of drivers are travelling within 4m of the vehicle in front.



Electric grid requirements

- The electric distribution grid should provide
  - Service continuity (equipment quality, redundancy)
  - Flexibility and extendibility (monitor demand growth)
  - Electrical efficiency
  - Power quality (voltage/frequency stability, harmonics)
  - Operational efficiency (Energy Management Systems)

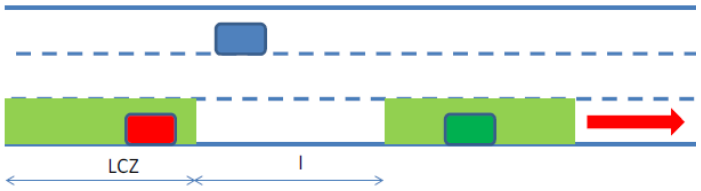
→ Wireless power transfer (WPT) must be designed in order to maintain operational grid requirements.

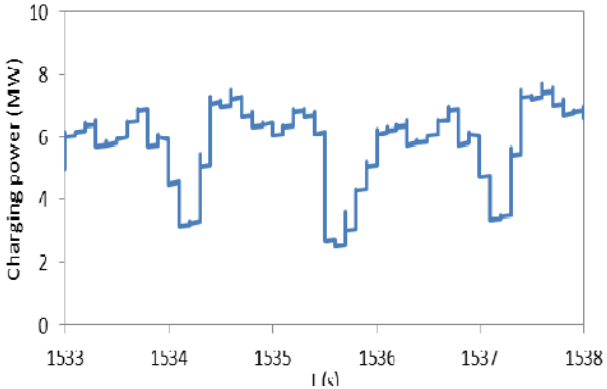
→ **Objective**: reduce grid connection costs with smooth and predictable demand

Electric grid requirements

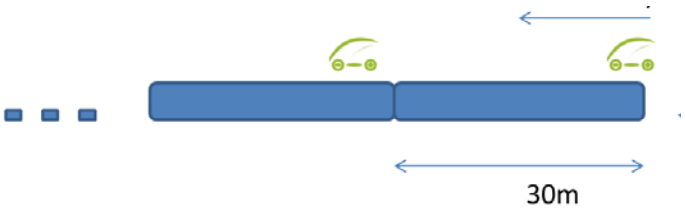
Effect of power transfer design

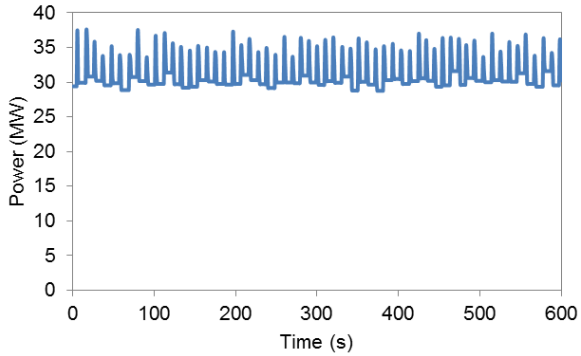
- Separated Power transfer pads: large fast fluctuations





- Contiguous Power transfer pads: reduced fluctuations

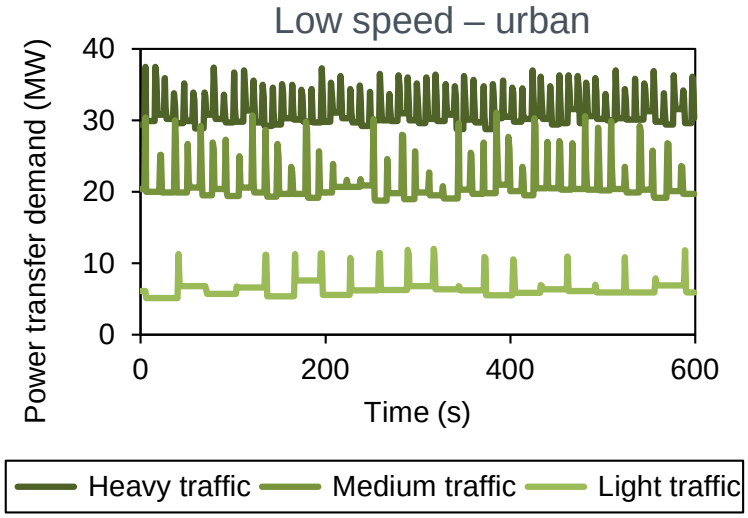




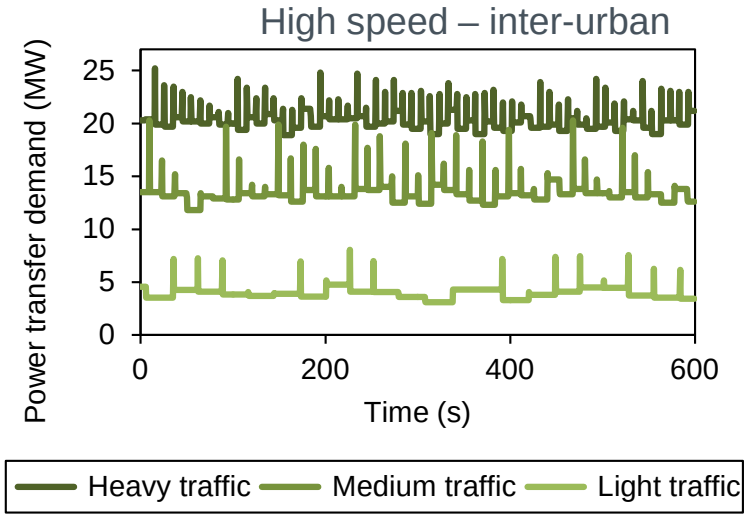
Electric grid requirements

Effect of traffic conditions

- Different densities at low speed (urban traffic, 36 km/h)
  - Higher demand
  - Larger fluctuations



- Different densities at high speed (inter-urban traffic , 108 km/h)
  - Lower demand
  - Less fluctuations

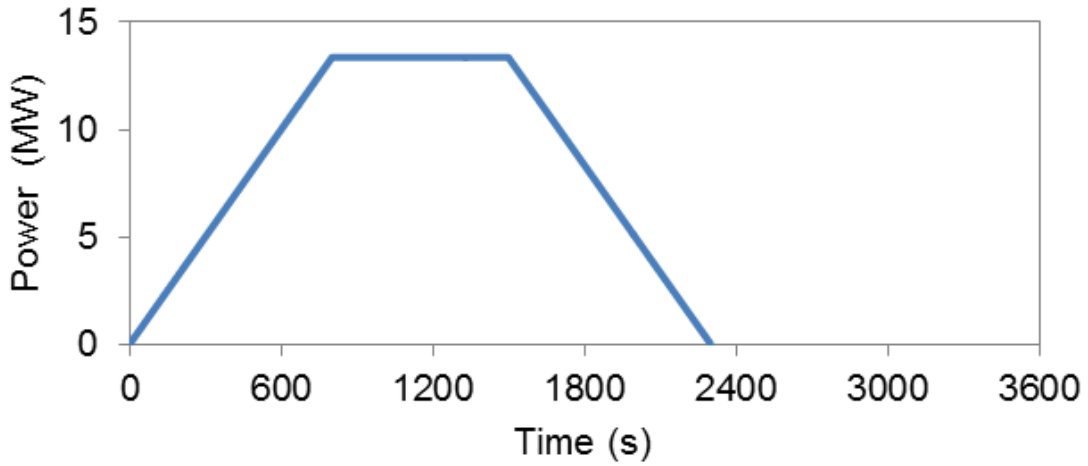


Electric grid requirements

Effect of traffic control

- Coordinated power transfer scenario
  - One vehicle at each power transfer pad
  - Contiguous pads
  - Constant speed and vehicle distance

→ Even in less perfect conditions, **platooning may reduce largely demand** peaks → Need for further investigation and model enhancements



Summary

- Tolerance to a misalignement of at least 15 cm
- WPT systems should be able to cope with a variable amount of vehicles on the road. (1-3 vehicles /30m)
- WPT solutions can be made grid friendly by
  - Adequate lane design
  - Additional infrastructure: energy storage
  - Additional systems: traffic control

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Thank you!

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