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 participant 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

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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

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

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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.
1. Results:

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

![Graph showing power over time]
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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