Autonomous Reversing of Heavy Goods Vehicles

Amy Rimmer, Andrew Odhams, David Cebon

Cambridge University
Presentation Outline

• Objectives and Background

• Modelling and Simulation

• Stability Analysis

• Conclusions and Future Work
Design an autonomous controller for reversing long combination vehicles
Long Combination Vehicles (LCVs)

- What is a Long Combination Vehicle?
Long Combination Vehicles (LCVs)

• What is a Long Combination Vehicle?

• Why Long Combination Vehicles?

<table>
<thead>
<tr>
<th>Performance Measure</th>
<th>Reduction due to LCVs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freight movements and overall truck-kms</td>
<td>44%</td>
</tr>
<tr>
<td>Overall shipping costs</td>
<td>29%</td>
</tr>
<tr>
<td>Fuel consumption / greenhouse gas emissions</td>
<td>32%</td>
</tr>
<tr>
<td>Road wear</td>
<td>40%</td>
</tr>
</tbody>
</table>
Long Combination Vehicles (LCVs)

• What is a Long Combination Vehicle?

• Why Long Combination Vehicles?

• How are LCVs reversed now?
Modelling

Tractor  B-link trailer  Semi-trailer

\[ \delta = f(y, \Gamma_1, \Gamma_2, L_p, K) \]
Stability Analysis

\[ \dot{z} = Mz \]
Eigenvalue Analysis

LEFT HALF PLANE

RIGHT HALF PLANE
Semi-Trailer: Root Locus
Semi-Trailer: Root Locus
Semi-Trailer: Root Locus

Unstable
Stable
Increasing K
Semi-Trailer: Root Locus

Unstable
Stable
Increasing K
Semi-Trailer: Root Locus

Unstable
Stable
Increasing $K$
Semi-Trailer: Root Locus

Unstable
Stable
Increasing K
Semi-Trailer: Root Locus

Unstable
Stable
Increasing K
Semi-Trailer: Root Locus

Unstable
Stable
Increasing $K$
B-Double: Root Locus

Unstable
Stable
Increasing K
B-Triple: Root Locus

Unstable
Stable
Increasing K
B-Quad: Root Locus

Unstable
Stable
Increasing K
Damping Ratio

0.9

0.5

0.1

0

-0.1

STABLE

MARGINALLY STABLE

UNSTABLE

DECREASING DAMPING RATIO
B-Double: Damping Ratio

Controller Gain, $K$

Preview Distance, $L_p$ [m]
Stability Thresholds ($\zeta=0$)

- B-Triple
- B-Double
- Tractor-Semi Trailer

Controller Gain, $K$
Preview Distance, $L_p$ [m]
0 5 10 15 20 25 30 35
0 10 20 30 40 50
Stability on a Curve

- Maximum preview distance $\sim R$

$y_{error} = \infty$
B-Double: Damping Ratio Comparison

R = 10

![Graph showing B-Double Damping Ratio Comparison with R = 10 for straight line and controller gain versus preview distance.](image)
Conclusions

• Controller stable for up to three trailers
• Stability decreases as number of trailers increases
• Trade-off between settling time and damping
• Control parameters can be tuned using straight line analysis
Future Work

• Develop alternative controllers

• Implement controller on test vehicle