Final Report on an Automated Truck Platoon within Energy ITS Project

October 13, 2013

International Task Force on Vehicle Highway Automation
17th Annual Meeting

Sadayuki Tsugawa
Meijo University
Japan
Outline

- Introduction of “Energy ITS” Project
- Automated Truck Platoon
  - Technologies
  - Effectiveness of platooning on energy saving and CO2 emission reduction
- Demonstrations
- Conclusions
Outline of “Energy ITS” Project

- Objectives: energy saving and CO2 emission reduction in road transportation

- Period: 2008FY – 2012FY

- Funding: METI* & NEDO**, about 4.4 billion yen in 5 years

- Themes
  - Automated truck platoon (3.9 B yen)
  - Evaluation method of effectiveness of ITS on CO2 emission reduction (0.5 B yen)

*METI: Ministry of Economy, Trade and Industry
**NEDO: New Energy and Industrial Technology Development Organization
Automated Truck Platoon

- Objectives
  - Energy saving and CO2 emission reduction by reduction of aerodynamic drag by platooning

- Technologies
  - Passive and active computer vision for lane marker detection for lateral control
  - Radar, laser scanner, and Inter-vehicle communications for gap measurement for longitudinal control

- Feature of the technologies: high reliability

- Goals
  - Fully automated truck platoon: 3 heavy automated trucks and 1 light automated truck at 80 km/h with 4 m gap
  - Cooperative ACC: 4 heavy trucks at 80 km/h with 30 m gap
Configuration of the Vehicles

- Steering actuator
- Laser scanner
- MMW RADAR
- Camera LI DARS
- V2VC antennas
- Vehicle control ECU
HMI for Drivers on the Followers

- Information to drivers on the dashboard and on the back of the leader

- Display
  - Acc/Dec/Braking display
  - Operating status
  - Position in a platoon
  - Gap & Leader Acc/Dec Display
  - Control switches
Passive Safety Device

- Shock absorber for 4 m platooning

(Left) trial device, (right) experiment
Fuel Saving by Platooning

3 truck platoon, empty-loaded, 80 km/h

![Graph showing fuel saving improvement vs. gap between trucks](graph.png)
### Performance of Platooning

<table>
<thead>
<tr>
<th>Items</th>
<th>Goal</th>
<th>Experiments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lateral control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Along straight line</td>
<td>±15 cm@80 km/h</td>
<td>±10 cm以下</td>
</tr>
<tr>
<td>Along a curved line (1000R)</td>
<td>±20 cm@80 km/h</td>
<td>±20 cm以下</td>
</tr>
<tr>
<td>Longitudinal control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steady state</td>
<td>±0.5 m@80 km/h</td>
<td>±0.5 m以下</td>
</tr>
<tr>
<td>Decelerating state</td>
<td>-1.5 m@0.2 G</td>
<td>-1.0 m以下</td>
</tr>
<tr>
<td></td>
<td>-3.0 m@0.5 G</td>
<td>-2.0 m以下</td>
</tr>
<tr>
<td>Fuel consumption reduction (3 trucks, flat road, empty-loaded)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gap=10 m</td>
<td>13 %</td>
<td>13.7 %</td>
</tr>
<tr>
<td>Gap=4.7 m</td>
<td>18 %</td>
<td>15.9 %</td>
</tr>
</tbody>
</table>
Effectiveness of Platooning on CO2 Emission Reduction

- Estimate of CO2 emission reduction by simulation
  - Roadway: Tomei expressway, Tokyo area, about 100 km
  - Traffic flow: light vehicles 69 %, heavy vehicles 31 %
  - Platoon rate: 40 % of heavy trucks

<table>
<thead>
<tr>
<th>Speed</th>
<th>Gap</th>
<th>Micro effect (less aero drag)</th>
<th>Macro effect (capacity Increase)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>80 km/h</td>
<td>10 m</td>
<td>2.0 %</td>
<td>0.1 %</td>
<td>2.1 %</td>
</tr>
<tr>
<td></td>
<td>4 m</td>
<td>3.5 %</td>
<td>1.3 %</td>
<td>4.8 %</td>
</tr>
</tbody>
</table>

Data: experiments in FY2010
Demonstrations

- Date & site: Feb. 25 – Mar. 1, 2013, AIST test track
- Menu (* test rides for visitors)
  - *Automated platoon of 3 heavy tracks, 80 km/h, 10 m gap
  - Automated platoon of 3 heavy tracks and 1 light track, 80 km/h, 4.7 m gap
  - *CACC of 4 heavy trucks, 80 km/h, 30 m gap
  - A fully automated light track, 50 km/h, lane changing & emergency braking
Acceptance of CACC

Experiments
- February, 2013; on a test track
- Subjects: 20 truck drivers and 9 freight company managers

<table>
<thead>
<tr>
<th>Category</th>
<th>Large</th>
<th>Medium</th>
<th>Small</th>
<th>Negative</th>
<th>No answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel economy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Workload reduction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Information service</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

0% 50% 100%
Conclusions

- Experiments of an automated truck platoon for energy saving and environment
- Features of the technologies: Highly reliable technologies of sensing, V2V communications and control
  - Requirements on reliability for introduction
- Issues on automated truck platooning
  - Legal and institutional issues
  - Market and acceptance