Energy ITS: What We Learned and What We should Learn

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TRB Road Vehicle Automation Workshop

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Outline

- Outline of “Energy ITS” project
- What we did and learned by now
- What we have to do and learn from now

Outline of the Project

- Objectives: energy saving and CO2 emission reduction for road transportation
- Period: FY2008 - FY2012
- Funding: METI & NEDO, about 4.4 billion yen in 5 years
- Themes
  - Automated truck platoon
  - Evaluation method of effectiveness of ITS on energy saving and CO2 emission reduction
- Contractors
  - Japan Automobile Research Institute
  - Universities, research institute, private companies

Automated Truck Platoon

- Technologies
  - Lane marker detection for lateral control
    - Passive and active computer vision
  - Gap measurement for longitudinal Control
    - Radar, laser scanner
    - Inter-vehicle communications
- Feature of the technologies: high reliability
- Goals
  - In March, 2010: 3 Heavy (25 t) trucks at 80 km/h with 10 m gap
    ➔ achieved
  - In March, 2013: 3 Heavy trucks and one light truck at 80 km/h with 4 m gap

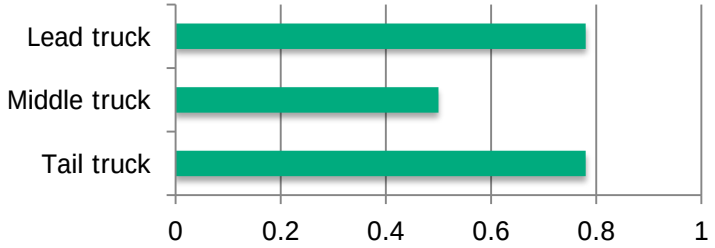
Videos: Platoon Engaging, Lane Changing, and Passenger Car Cut-in

Vehicle Control Performance

Driving site		Test track		Expressway Before public use	
		Goals	Results	Goals	Results
Vehicle speed		80 [km/h]		80 [km/h]	
Lateral control		± 20 [cm]	± 6 [cm]	± 20 [cm]	± 15 [cm]
Longitudinal Control	Steady state	10±2 [m]	10±1 [m]	10±2 [m]	10± [m]
	Braking at 0.5 G	10-3 [m]	10±1 [m]	10±3 [m]	10±1 [m]
Lane changing (target path following)		± 7 %	± 10 %	± 7 %	± 15 %
Time to form a platoon		15 [s]	32 [s]	N/A	N/A

Effects of Platooning on Energy Saving

- CFD simulation result: CD values of each truck
  - Driving at 80 km/h with 4 m gap
  - CD value of a single truck=1



- Energy saving owing to less aerodynamic drag
  - Measurement when driving at 80 km/h with 10 m gap

Driving site	Driving distance	Energy consumption improvement			
		Lead truck	Middle truck	Tail truck	Mean
Expressway before public use	8.0 km * 3 times	+7.5 %	+18 %	+16 %	+14 %
Test track (oval)	About 100 km	+10.0 %	+17.5 %	+14 %	+13.8 %

Effects 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

Gap	Speed	Micro effect (less aero drag)	Macro effect (capacity Increase)	Total
10 m	80 km/h	2.0 %	0.1 %	2.1 %
4 m		3.5 %	1.3 %	4.8 %

Technological Issues

- Quantitative evaluation of the reliability of the equipment
  - Required MTBF of the equipment for introduction
- Passive safety
  - Passive safety device will be necessary when the gap is small
- HMI
  - Information to drivers in the following trucks
  - Information to drivers around a platoon

Reliability of the Equipment: Current Status of the Trucks

Functions	Devices	Reliability improvement
Lane marker detection	Computer vision (ordinary CCD camera, laser scanner+PD, LED+CCD camera)	Plurality of sensors of different operating principles
Obstacle detection	MMW radar LRF Infrared stereo vision	
Gap measurement		
Electronic control unit		Fail safe Detection of faults
V2V communications	5.8 GHz DSRC	Plurality of communication units of different media and operating principles
	Infrared	
Steering actuator	Electric motors	Independent 2 motors
Braking actuator	WABCO	
Throttle actuator	diesel	

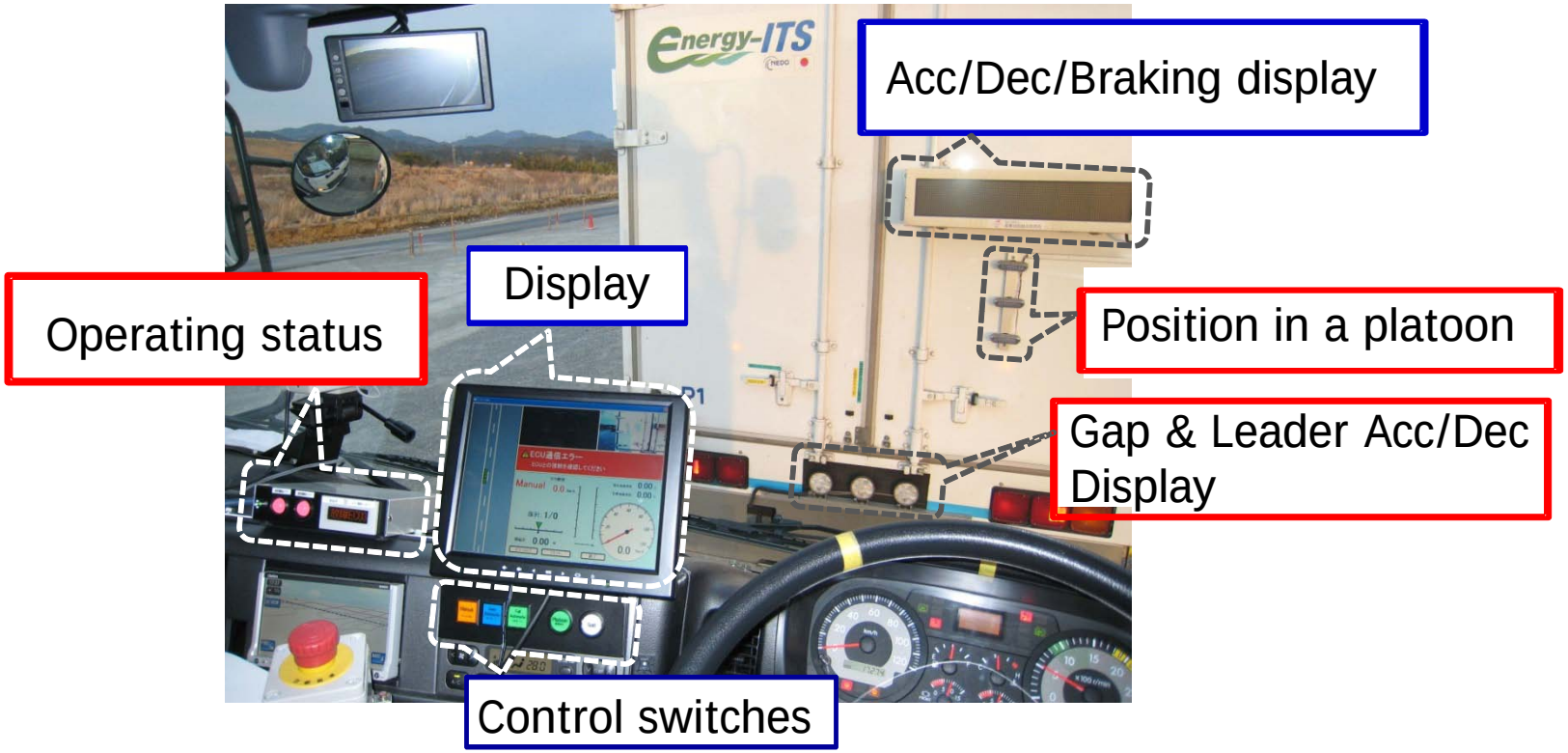
Passive Safety Device

- Shock absorber
  - Under development for 4 m platooning

(left) trial device, (right) experiment

HMI for Drivers on the Followers

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



Market Research

- Backgrounds of freight operators in Japan
  - Tough competitiveness
  - Profit-sensitive, cost-sensitive
- Interview to freight operators
  - After trial ride along an expressway on March 2011 (80 km/h, 10 m gap)
  - Expectations on platooning
    - Energy saving: yes (91%)
    - Congestion reduction: yes (79%)
    - Load damage reduction: yes (73%)
    - High company brand image: yes (60%)
    - Safe driving: yes (39%), unknown (39%), no (21%)
    - Workload reduction: no (67%), unknown (18%), yes(15%)

Issues on Operation

- Places to engage/disengage a platoon
  - Current plan: on expressways while driving
- When different freight companies make a platoon,
  - How the benefits (positive and negative) are shared among them?
  - Responsibility of an accident

Legal and Institutional Issues on Automated Truck Platoon

Automation levels	Issues	Backgrounds / Notes	Currently Permitted?
Driver assistance systems	Drivers on each truck, 40 m gap ACC (1.8 sec gap)		Yes
	Drivers on each truck, 10 m gap	A platoon may be an obstacle to other vehicles	No
	Drivers on each truck, 4 m gap	Drivers on following trucks cannot operate due to small FOV	No
Automated driving systems	The first truck is driven by a driver, and automated, unmanned trucks follow	Can it be regarded as a long single vehicle?	No

Introduction Scenario of a Truck platoon (2012 July version)

	Near Future	Mid Future	Far Future
Concept	- ACC - driver assistance	- CACC (ACC + V2V) - driver assistance	- CACC - automated lateral control
Roadway	Expressways, mixed traffic		
System objectives	- elimination of congestion at sags	- safer system - eco driving - smooth traffic	- much safer system - energy saving - workload reduction
Gap [sec]	1.8 – 1.0	1.0 - 0.9	0.9-0.3
Control objectives		- warning to drivers and control of brakes on emergency braking of a lead vehicle	- short gap keeping - lane keeping
Drivers	on each truck	on each truck	on each truck or only on the lead truck
Notes	(1.8 s gap) no legal and institutional issues, and can be introduced	- ACC gap for trucks is 1.8 s while that for passenger cars is 1.0 s according to the Japanese guidelines - Truck ACC is in the market, but freight companies prohibit their drivers from the use due to accidents	

Conclusions

- Technological results of Energy ITS Project
  - At present, a platoon of 3 automated trucks driving at 80 km/h with 10 m gap
  - Effectiveness of energy saving and CO2 emission reduction
- Technologies issues
  - Reliability of the equipment
- Non-technological issues
  - Operational issues
    - Locations to engage/disengage a platoon
  - Legal and institutional issues
    - What kind of (semi-) automated trucks are permitted?

Energy ITS Workshop in Vienna

- Date: October 22 (Monday), 2012
- Time: 9 am – 3 pm
- Venue: Vienna Convention Center (the same place of 19th ITS World Congress)
- Program
  - Detailed report of automated truck platoon
  - Progress in US and EU (planned)

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