DAIMLER

Supporting the driver in conserving energy and reducing emissions
- Daimler Trucks ecoDriver assistance experience -

Roland Trauter

EGVIA Workshop European funded project results:
Reduction of CO2 emissions from Heavy-Duty Trucks
Brussels, May 31st 2017

Daimler Trucks

Co-funded by

www.ecodriver-project.eu

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Thomas BUILT BUSES

BHARATBENZ

ecoDriver

Supporting the driver
in conserving energy
and reducing emissions

Project co-funded by the European Commission
7th Framework Programme for Research and Development

- October 2011 – September 2015 (48 months)
- Extended until March 2016
- Project Budget: 14, 5 Mio. €
- Project coordinator: University of Leeds

Consortium Partners:

ITS University of Leeds, TNO, vti, IFSTTAR, ika, CTAG Centro Tecnológico de Automoción de Galicia, CRF Centro Ricerche Fiat, ERTICO ITS Europe, TomTom, BMW Group Forschung und Technik, Daimler

Daimler Trucks ecoDriver Objectives

⇒ Complete existing Truck Technolgies and Eco Solutions

- EURO VI Engine Platform
- Automated Gear Shifting Powershift
- Eco Roll (automated shift to neutral gear)
- Predictive Powertrain Control (Cruise Control Driving)
- Fleetboard Eco Support (Eco Driver Feedback)
- Eco-Training for Drivers and Fleet Managers

=> Develop ecoDriver System for safe and fuel-efficient driving!

Driver support for driving with accelerator pedal (non cruise-control) and automated shifting

⇒ Expected Benefits

- Retain investment in initial Eco-Training by continuous onboard training
- Fuel consumption reduction target 1 – 3 % / Reduced emissions
- Improved driving safety and driver comfort

Eco-Driving for commercial goods transportation

- Ecological target given by emission regulations EURO VI
- Economical target enforced by competition on EU market

- ecoDriver supports driver and thus depends on driver acceptance and motivation !

- Truck driver is typically not truck owner !
- Driver feedback on motivation and priorities .....

Safety	Yes !!	Fuel consumption	No / lower priority ?
Time	Yes !	Emissions	No / lower priority ?
Comfort	Yes !		

- Driver motivation for fuel saving / emission reduction / ecoDriving needs incentivation !

Daimler Trucks ecoDriver Project Work

- ecoDriver Team from Daimler Trucks Advanced Engineering and Daimler Research & Development

⇒ **Development of ecoDriver application prototype**

- Solution approach: Fuel-efficient driving with a map-based route preview
- Identification of use cases with fuel saving protential
- Driving strategy calculation that supports defined use-cases
- Multi-modal HMI for continuous Driver Guidance with feed forward and feedback

⇒ **Public Road Evaluation of ecoDriver application prototype**

- Early prototype testing with series truck during development with data collection
- Acceptance Study with external truck drivers including data collection
- Management Demonstration Drives / Winter Test Finland 2015
- Public Final Event Demonstration Drives March 2016

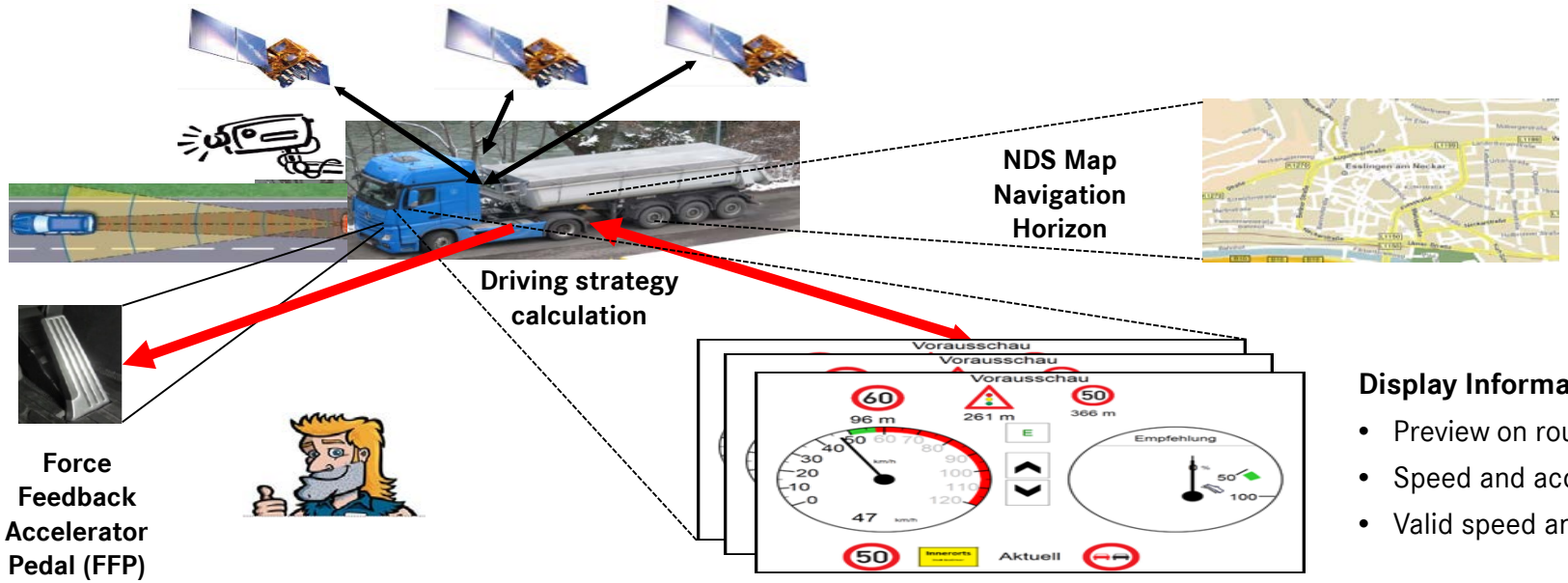
⇒ **Evaluation of ecoDriver Efficiency and expected Impact together with ecoDriver Partners**

- Joint analysis of Driver Feedback from Acceptance Study
- Joint analysis of collected data with focus on driver behaviour and effects on fuel consumption and emissions

Daimler ecoDriver application prototype

=> Driver Information System for safe and fuel-efficient driving!

Driving with accelerator pedal (non cruise-control) and automated shifting

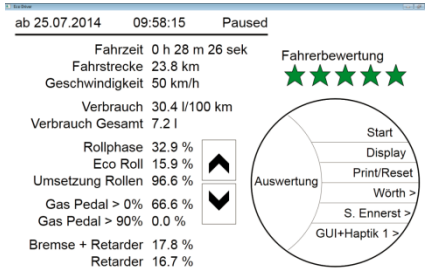


Display Information / Graphical User Interface (GUI)

- Preview on route course and restrictions
- Speed and acceleration recommendation
- Valid speed and overtaking restrictions

Haptic Information

- Variable pressure point for acceleration recommendation
- Knocking signal for speed and safety distance violations

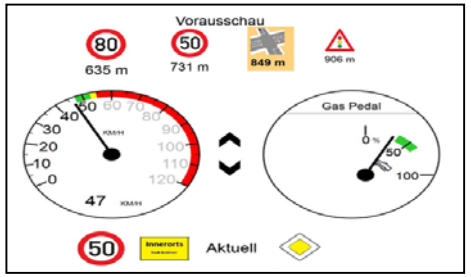


Display Information / Graphical User Interface (GUI)

- Driver rating
- Trip data

ecoDriver assistance prototype use cases

- Series truck Actros 1851 with trailer - 30 to -
- + ecoDriver assistance prototype equipment



Driving strategy supports use cases

- Roll over hilltop
- Steep hill acceleration
- Curve driving
- Speed limit roll out / acceleration
- Stop sign / intersection approach
- Overtaking restriction
- Sink coasting / acceleration
- Downhill acceleration / ecoRoll
- Preceeding vehicle distance
- Round-about approach

Driver observes traffic and controls truck: No autonomous driving

Daimler ecoDriver Acceptance Study on public roads

=> Full-day test-trips with 24 external professional truck drivers

- Actros 1851 with dumper (30 to) equipped with ecoDriver prototype
- Test route 263 km: Stuttgart – Esslingen – Münsingen - Stuttgart
- City – motorway / larger part rural roads – hilly terrain – dangerous curves
- Driving without ecoDriver (series), with ecoDriver GUI and with ecoDriver GUI + Haptic Pedal(FFP)

		Stuttgart - Esslingen - Stuttgart	**Münsingen – Ennabeuren - Münsingen**				**Münsigen - Stuttgart**	
8 Drivers	Briefing & Attitude	Serie	ecoDriver GUI	ecoDriver GUI & FFP	Break & Questionnaire	Serie	ecoDriver GUI	Feedback & Assessment
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8 Drivers	Briefing & Attitude	ecoDriver GUI & FFP	Serie	ecoDriver GUI	Break & Questionnaire	ecoDriver GUI & FFP	Serie	Feedback & Assessment

Documentation

- Questionnaire for Driver
- Notes from observers
- Logging of vehicle and ecoDriver data

Daimler ecoDriver Acceptance Study: Driver Feedback Summary

- Motivation for eco driving improved from neutral to positive after test trip

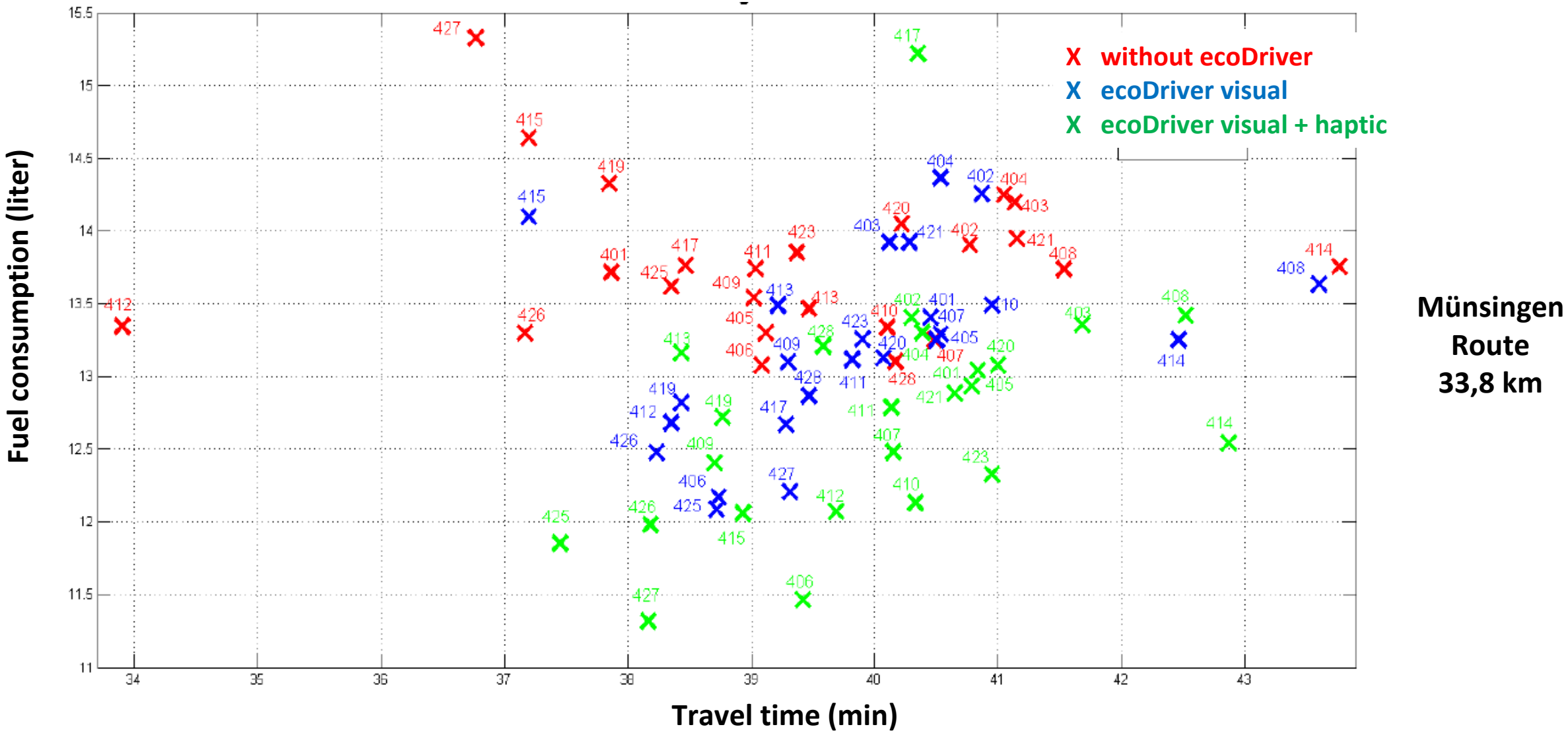
- Usefulness of haptic information/ Force Feedback Accelerator Pedal confirmed 100%
- Usefulness of combined visual (display) and haptic (pedal) information confirmed 79%
- Usefulness of only visual information (display) depending on position confirmed 67%
- Driving comfort and safety feeling optimal with combined visual and haptic information

- Driving with only visual information requires higher concentration/ is felt distracting
- Concerns to block traffic flow with extensive roll out / speed reduction

- Performance, usability, efficiency of complete ecoDriver system is rated as very good

Daimler ecoDriver Acceptance Study:

Examples Fuel Consumption and Drive Time



Münsingen
Route
33,8 km

Daimler ecoDriver Acceptance Study:

Examples Fuel Consumption

Driver No.	System	Route lenght(km)	No. Of stops	Fuel consumption (l/ 100 km)	Fuel consumption (l)	Fuel consumption difference (%)
419	Serie	33,7	0	42,4	14,3	-
419	ED GUI	33,7	0	38	12,8	-10,49%
419	ED GUI+FFP	33,7	0	37,7	12,7	-11,19%
420	Serie	33,8	2	41,4	14	-
420	ED GUI	33,8	1	38,8	13,1	-6,43%
420	ED GUI+FFP	33,8	1	38,6	13,1	-6,43%
421	Serie	33,9	2	41,1	13,9	-
421	ED GUI	33,8	3	41,1	13,9	0,00%
421	ED GUI+FFP	33,8	0	38	12,9	-7,19%
423	Serie	33,8	2	40,9	13,8	-
423	ED GUI	33,8	0	39,1	13,2	-4,35%
423	ED GUI+FFP	33,8	5	36,4	12,3	-10,87%
425	Serie	33,8	3	40,3	13,6	-
425	ED GUI	33,8	1	35,8	12,1	-11,03%
425	ED GUI+FFP	33,8	2	35,1	11,8	-13,24%
426	Serie	33,8	1	39,3	13,3	-
426	ED GUI	33,8	0	36,9	12,5	-6,02%
426	ED GUI+FFP	33,8	1	35,5	12	-9,77%
427	Serie	33,8	2	45,2	15,3	-
427	ED GUI	33,8	1	36,1	12,2	-20,26%
427	ED GUI+FFP	33,8	1	33,4	11,3	-26,14%

Daimler ecoDriver Acceptance Study:

Average Values Fuel Consumption and Drive Time

Stuttgart - Esslingen - Münsingen (90 km)	Serie	GUI	GUI-FFP
Average driving time [min]	114,53	116,25	117,68
Difference driving time [%]	0,00	**1,50**	**2,74**
Min driving time [min]	110,05	111,22	114,47
Max driving time [min]	119,85	124,45	122,23
Average fuel consumption [l]	40,99	40,88	39,60
Difference fuel consumption [%]	0,00	**-0,27**	**-3,39**
Min fuel consumption [l]	40,00	39,80	38,40
Max fuel consumption [l]	42,60	42,60	40,40

Münsingen - Münsingen (34 km x 3)	Serie	GUI	GUI+FFP
Average driving time [min]	39,54	39,85	39,97
Difference driving time [%]	0,00	**0,79**	**1,09**
Min driving time [min]	36,77	37,20	37,45
Max driving time [min]	43,77	43,60	42,87
Average fuel consumption [l]	13,74	13,17	12,68
Difference fuel consumption [%]	0,00	**-4,13**	**-7,67**
Min fuel consumption [l]	13,10	12,10	11,30
Max fuel consumption [l]	15,30	14,20	15,20

Münsingen - Stuttgart (72 km)	Serie	GUI	GUI+FFP
Average driving time [min]	87,79	91,72	91,60
Difference driving time [%]	0,00	**4,48**	**4,34**
Min driving time [min]	83,83	85,40	88,00
Max driving time [min]	91,82	96,55	95,42
Average fuel consumption [l]	21,09	19,40	18,65
Difference fuel consumption [%]	0,00	**-8,00**	**-11,56**
Min fuel consumption [l]	19,40	18,40	18,00
Max fuel consumption [l]	23,60	20,70	19,60

Stuttgart - Esslingen - Münsingen, Münsingen - Münsingen, Münsingen - Stuttgart (263 km)	Serie	GUI	GUI+FFP
Average driving time [min]	320,93	327,51	329,18
Difference driving time [%]	0,00	**2,05**	**2,57**
Average fuel consumption [l]	103,29	99,79	96,30
Difference fuel consumption [%]	0,00	**-3,39**	**-6,77**

Daimler ecoDriver Acceptance Study:

Example Driver Rating (Screenshots from Display)

Fahrzeit	0 h 36 m 46 sek
Fahrstrecke	33.8 km
Geschwindigkeit	55 km/h
Verbrauch	45.2 l/100 km
Verbrauch Gesamt	15.3 l
Rollphase	38.3 %
Eco Roll	3.9 %
Umsetzung Rollen	63.8 %
Gas Pedal > 0%	61.5 %
Gas Pedal > 90%	20.4 %

Trip data without ecoDriver assistance

Fahrzeit	0 h 38 m 10 sek
Fahrstrecke	33.8 km
Geschwindigkeit	53 km/h
Verbrauch	33.4 l/100 km
Verbrauch Gesamt	11.3 l
Rollphase	50.3 %
Eco Roll	21.8 %
Umsetzung Rollen	98.1 %
Gas Pedal > 0%	49.7 %
Gas Pedal > 90%	2.5 %

Trip data with ecoDriver GUI + Haptic pedal
Excellent driver performance

Results and conclusions

- **ecoDriver assistance approved benefits:**
  - 50 000 km on-road measuring and acceptance testing
  - Improved driving comfort and safety
  - Fuel savings Range: 0 – 25 % Average ecoDriver GUI: 3,4 % ecoDriver GUI + FFP: 6,8 %

- **Timing of input data and computation time is critical**

- **Limitations:**
  - Bad weather (ice, snow): Priority on safety
  - High traffic density, jam, rush hour : Driver follows traffic flow

ecoDriver assistance works on-road

Thank you for your attention !

Questions !