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Mehr Wert.

Langenau, 15.09.2010
Unsere Zeichen: ce
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Certification of a procedure developed by IVECO Magirus AG Ulm to calculate relative fuel savings

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1) Context

In the EU there is no binding law for determining the fuel consumption at N3 vehicles. For N1 vehicles, the fuel consumption after 80/1268/EEC Annex I is calculated in accordance with Section 6 of the hydrocarbon, carbon monoxide and carbon dioxide emissions. But this can not be applied to vehicles of category N3.

Commercial vehicle manufacturers face the task that if something in the driveline or engine is modified, it is not possible to see immediately the impact on fuel consumption in real driving condition. In the case of LGVs, the exterior design of the trailer/semi-trailer is also often a major factor in determining fuel consumption.

IVECO Magirus AG of Ulm, Germany has developed a procedure whereby the relative fuel saving achieved by a given modification can be ascertained from comparative test drives on different types of road (single-carriageway highways, motorways etc.), without factors that affect absolute fuel consumption (e.g. the weather) distorting the result.

An unchanged standard truck-trailer-combination gives a 100% reference for each measurement run. All tests are carried out on representative roads.

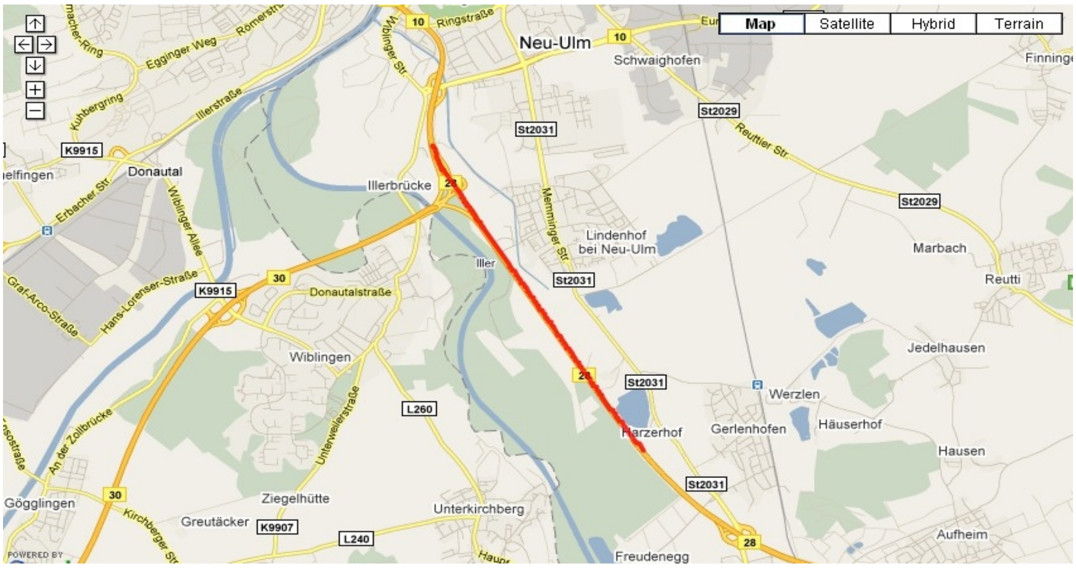
It was shown that the process is accurate enough to make statements about how technical changes on the tractor, the trailer or a combination of both influence the fuel consumption.

This procedure is not intended to measure absolute fuel consumption. However, as a comparative method, it is suitable for quantifying the effect of any modifications to the overall design of the vehicle, such as, for example, the effect of different semi-trailer designs.

2) Test layout

This section describes how the comparison process works

2.1) Test Routes



Constant speed runs at 85 km/h and 90 km/h with different vehicle configurations are conducted on the B 28 between Neu Ulm and Senden. Measurements are taken from km 7.5 to km 4.5 on the outward leg, and from km 7.5 to km 4.5 on the return leg. The weather conditions are recorded for each run.

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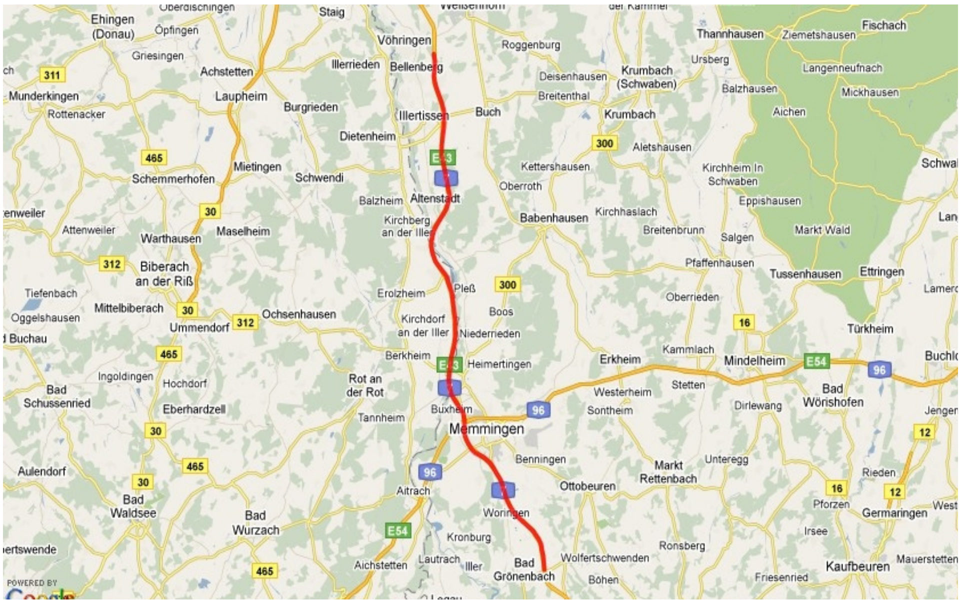

Picture 2 Track for constant speeds on highway (©Google MAP)

Constant-speed runs on the motorway at 85 km/h and 90 km/h with different vehicle configurations are conducted on the A 7 between Neu Ulm and Memmingen. Measurements are taken from km 858 to km 904.5 on the outward leg, and from km 904.5 to km 858 on the return leg. The weather conditions are recorded for each run. At 47.5 km in length, this route is longer by a factor of 12, and as such will show the relative fuel saving in real-world conditions.

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2.2) Test vehicles

Reference tractor 1 Comparison tractor 2

	FL-T11	C10-E5-2
Vehicle	Stralis (current production specification)	ECOSTRALIS
Type	ASL 440 S 45 T/P	AT-N 440 S 46 T/P
VIN	XXX	XXX
VAN	XXX	XXX
Version	Stralis Active Space With high roof	Stralis Active Time with high roof
Aerodynamic components	Roof spoiler Side flaps Chassis side skirts	Roof spoiler Side flaps Chassis side skirts
Wheelbase	3,650 mm	3,800 mm
Engine	Cursor 10	Cursor 10
Engine type	F3AE3681A	F3AE3681A
Engine management data	XXX	XXX
Output	332 kW/450 PS	338 kW/460 PS
Torque	2,100 Nm	2,100 Nm
Emissions standard	EEV	EEV
Engine oil	5W30	5W30
Engine braking	Decompression & VGT	Decompression & VGT
Transmission	ZF 12 AS 2331 TD	ZF 12 AS 2330 TD
Retarder	ZF Intarder	none
Axle ratio	i=2.85	i=2.64
Tyres, front	385/55R22.5 Michelin XFA 2 Energy	315/70R22.5 Michelin Energy Savergreen XF
Tyres, rear	315/70R22.5 Michelin XDA 2 Energy	315/70R22.5 Michelin Energy Savergreen XD

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Reference tractor 1 Comparison tractor 3

	FL-T11	FL-T1
Vehicle	Stralis current series	ECOSTRALIS
Type	ASL 440 S 45 T/P	ASL 440 S 46 T/P
VIN	XXX	XXX
VAN	XXX	XXX
Version	Stralis Active Space with high roof	Stralis Active Space with high roof
Aerodynamics	Dachspoiler Sideflaps Chassis side cover	Dachspoiler Sideflaps Chassis side cover
Wheelbase	3650 mm	3650 mm
Engine	Cursor 10	Cursor 10
Engine type	F3AE3681A	F3AE3681A
Motor data	XXX	XXX
Performance	332 kw / 450 PS	338 kw / 460 PS
Torque	2100Nm	2100Nm
Emission	EEV	EEV
Motor Oil	5W30	5W30
Engine Brake	Decompression & VGT	Decompression & VGT
Transmission	ZF 12 AS 2331 TD	ZF 12 AS 2331 TD
Retarder	Intarder	ZF Intarder
Final drive ratio	i=2,85	i=2,64
Front tires	385/55R22,5 Michelin XFA 2 Engergy	315/70R22,5 Michelin Engergy Savergreen XF
Rear tires	315/70R22,5 Michelin XDA 2 Engergy	315/70R22,5 Michelin Engergy Savergreen XD

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	Reference trailer 1	Comparison trailer 2
Manufacturer	Brand A	Brand B
Type	Model 1	Model 2
VIN	XXX	XXX
Aerodynamics	not optimized	Aerodynamic front wall panel, front, side and rear panel, smooth side curtains
Wheelbase	1360 mm;1360 mm	1810 mm
Configuration	Curtainsider	Curtainsider
Dimension B	12000 mm	12000 mm
zGG	35000 kg	32000 kg
permissible axle load per axle	8000 kg	10000 kg
Number of axles	3	2
tires	385/65R22,5 Continental HTR 2	385/65R22,5 GoodYear RHT2, 5t Traglast

	Reference trailer 1	Comparison trailer 3
Manufacturer	Brand A	Brand A
Type	Model 1	Model 1
VIN	XXX	XXX
Aerodynamics	not optimized	not optimized
Wheelbase	1360 mm;1360 mm	1360 mm;1360 mm
Configuration	Curtainsider	Curtainsider
Dimension B	12000 mm	12000 mm
zGG	35000 kg	35000 kg
Permissible axle load per axle	8000 kg	8000 kg
Number of axles	3	3
Tires	385/65R22,5 Continental HTR 2	385/65R22,5 Continental HTR 2

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	Reference trailer	Comparison trailer
Manufacturer	Brand A	Brand B
Type	Model 1	Model 3
VIN	XXX	XXX
Aerodynamics	not optimized	not optimized
Wheelbase	1360 mm;1360 mm	1310 mm;1310 mm
Aufbauart	Curtainsider	Curtainsider
Dimension B	12000 mm	12000 mm
zGG	35000 kg	35000 kg
Permissible axle load per axle	8000 kg	8000 kg
Number of axles	3	3
Tires	385/65R22,5 Continental HTR 2	385/65R22,5 GoodYear Regional RHT

2.3) Process design

The test vehicle drives the short route (B 28) four times in each direction, and an average is calculated for these eight runs. The longer route (A 7) is driven only two times in each direction, meaning a total of four measurements are taken.

Data recording is started and stopped manually at set way points. The exact position at which recording is stopped/started can be checked using a GPS system.

For the comparison series which only determine the differences between tractors, identical trailers (reference trailer 1 and comparison trailer 3) are used. For those trailers, which are regularly exchanged during measurement sequence, an initial coast down measurement (Peiseler wheel based) was carried out in order to ensure identical driving resistances.

In the test sequences with variation of the trailer, an unchanged reference combination (tractor 1 with the semitrailer 1) constantly accompanies the measurement vehicle in order to detect changes in weather and outer impacts.

On the short test route, the vehicles drive at a constant 85 km/h on cruise control.
In case of significant traffic impact (aerodynamic drag) the measurement is cancelled and repeated.
All vehicle control systems (such as transmission control) are operated in automatic mode without driver intervention.
Measurement vehicle and reference vehicle drive each in immediate sequence (target distance 100-500 meters), so that for both wind and weather conditions are as equal as possible. Distances of less than 50 m are strictly avoided in order to prevent mutual aerodynamic influences, that become relevant below about 40 m (determined by test).

On the long test route, the vehicles drive at a constant speed on cruise control. All vehicle control systems (such as transmission control) are operated in automatic mode without driver intervention.
Measurement vehicle and reference vehicle start also in immediate sequence (target distance 100 to 500 meters).

Because the test is conducted on a public road with other traffic, factors such as gradients and short-term slip-streaming effects from overtaking vehicles will affect the result. The long length of the route and the repeated test runs are intended to compensate for these.

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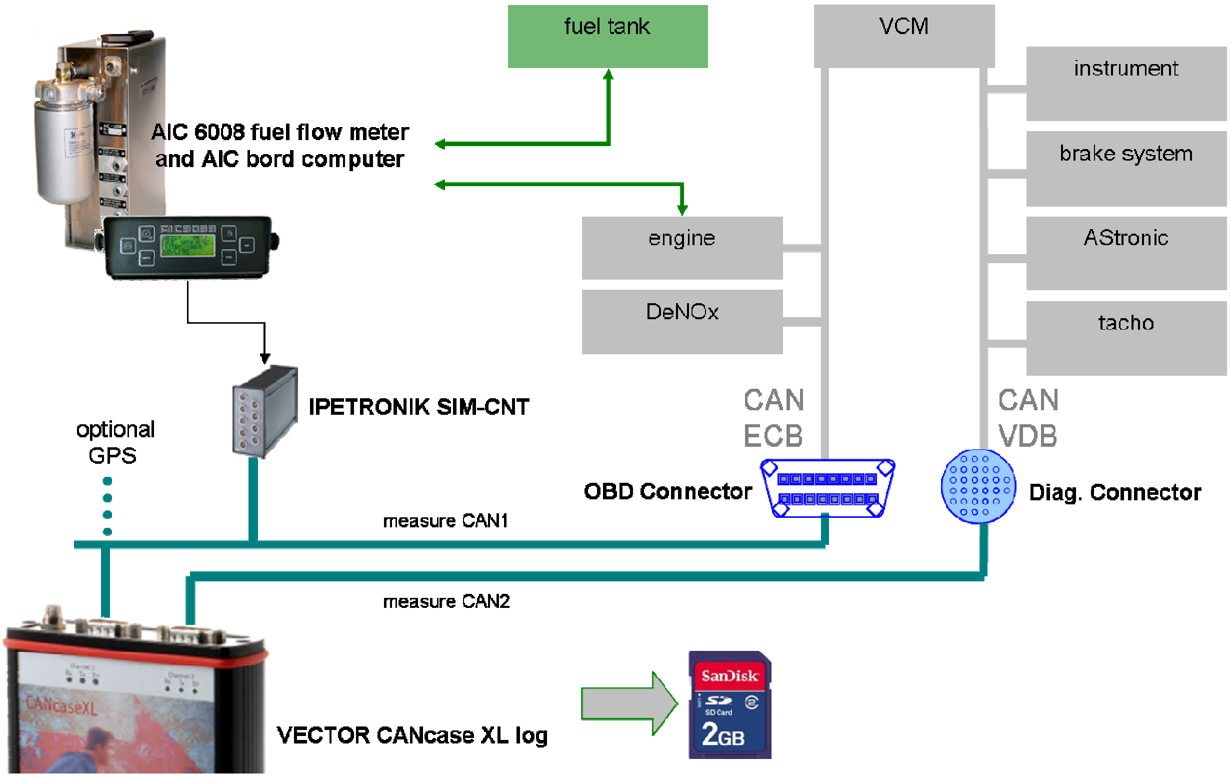
3) Measurement methodology

3.1) Data capture

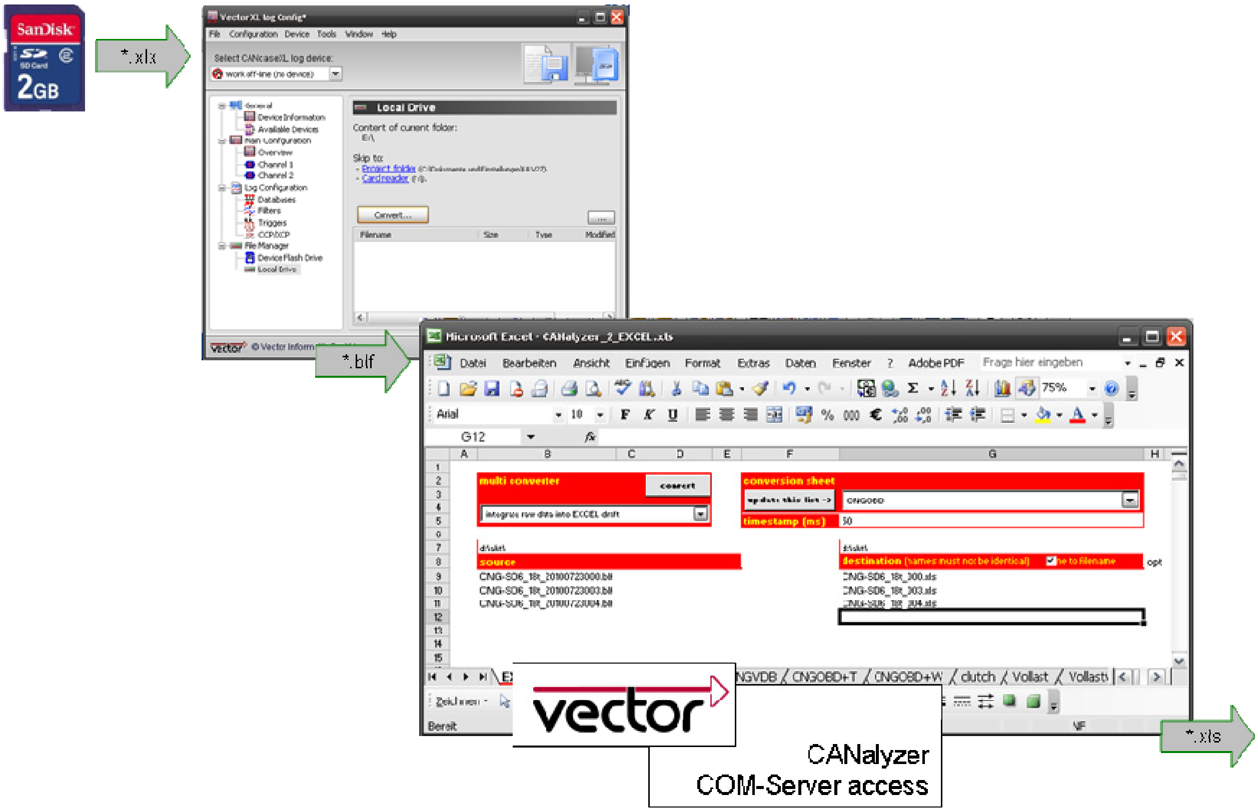


Picture 3 Scheme of data collection

A flow meter (type 6008 AIC Uni Flow Master) measures the actual fuel consumption. Additional data such as engine temperature, torque, coolant temperature, vehicle speed, etc. are acquired via CAN-Bus. The data collected is recorded by a data logger and written to a memory card. This card can be read out after the test cycle by a PC.

The data logger used is a CANcase XL, which in mobile use has an operating temperature range of -20 to +70°C. All measurements are time-stamped to an accuracy of 1 microsecond.

3.2) Data evaluation



Picture 4 Scheme of the data analysis

The data captured during the tests is stored on a memory card. This can then be uploaded to a PC by a software application made by Vector Informatik of Stuttgart.

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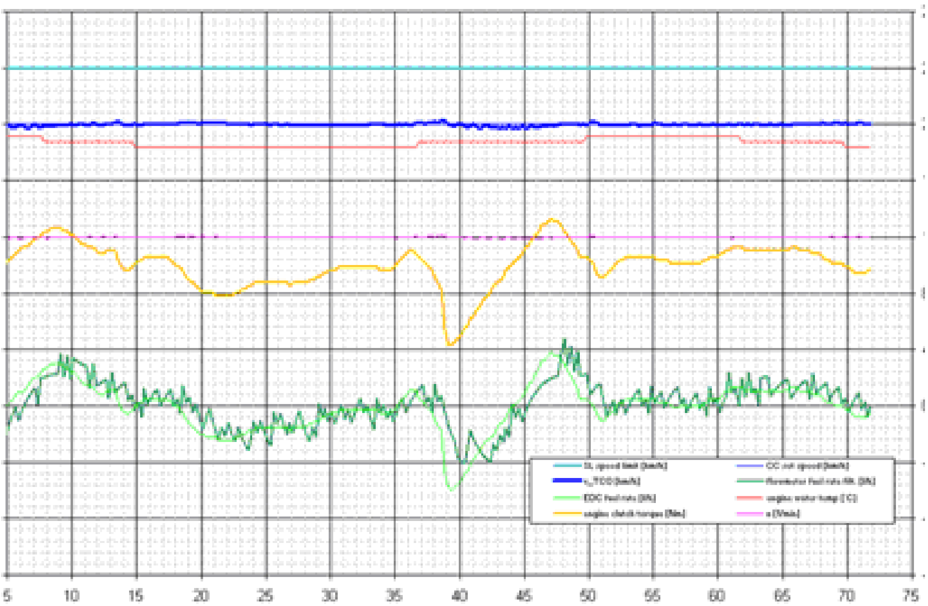
After macro based post processing it is possible to visualize the data graphically or in a evaluable file.



Picture 5 Example of a graphical representation

date/time of measurement start 20100630_11-46-59

	length of measurement	70,75	s
flowmeter	total fuel used (dyn)	0,5938	l
EDC	total fuel used (dyn)	0,5828	l
	total urea used (dyn)	0,0234	l
	urea/fuel	4,0184	%
tachograph	distance	1,5707	km
	average speed	79,92	km/h
	fuel consumption (flowmeter)	37,80	l/100km
	fuel consumption (EDC)	37,10	l/100km
	urea consumption	1,49	l/100km
tachograph corrected	distance		km
	average speed		km/h
	fuel consumption (flowmeter)		l/100km
	fuel consumption (EDC)		l/100km
	urea consumption		l/100km
GPS	distance		km
	average speed		km/h
	fuel consumption (flowmeter)		l/100km
	fuel consumption (EDC)		l/100km
	urea consumption		l/100km
tachograph data	start	21094,22	km
	end	21095,77	km

Picture 6 Example of a tabular representation

4) Test results

The reference combination (tractor 1 and trailer 1) always gives similar results for fuel consumption over the complete test period.

The following adjustments are therefore made to the data recorded for the test vehicles:

1. Linear correction of reference vehicle fuel consumption to the target speed.
2. Linear correction of test vehicle fuel consumption to the target speed.
3. Linear correction of test vehicle fuel consumption to the deviation in fuel consumption of the reference vehicle.

So, if on a particular day, the observed fuel consumption for the reference vehicle deviates by 1% from the reference figure, then a 1% adjustment should also be made to the observed figure for the test vehicle. This represents the effect of weather conditions.

The reference vehicle corresponds to the current production specifications. The test vehicles have been modified as described in section 2.2.

4.1) Test runs

Test 1

In test 1, the combination of tractor 3 and trailer 3 was compared with the control vehicle (tractor 1 and trailer 1). This test was conducted using the short route, on the B 28. Each combination completed four runs in each direction.

The semi-trailers were swapped over after every two runs (tractor 1 + trailer 3; tractor 3 + trailer 1), to minimize the effect of the trailer on the result.

Test conditions:

Weather	Sunny
Wind speed	< 1.5 m/s
Temperature	13-16°C
Reference vehicle weight	39.97 t
Test vehicle weight	39.86 t
Speed	86 km/h

Results for test 1

Combination	Fuel consumption as a %
1 + 1	100
3 + 3	95.23

Fuel saving achieved by test combination: *4.77%*

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Test 1.1

In test 1.1, the combination of tractor 3 and trailer 3 was compared with the control vehicle (tractor 1 and trailer 1). This test was conducted using the long route, on the A 7. Each combination completed two runs in each direction.

The semi-trailers and drivers were swapped over after every run (tractor 1 + trailer 3; tractor 3 + trailer 1), to minimize the effect of these variables on the result.

Test conditions:

Weather	Sunny
Wind speed	< 3.0m/s
Temperature	16°C
Reference vehicle weight	39.97 t
Test vehicle weight	39.86 t
Speed	86 km/h

Results for test 1.1

Combination	Fuel consumption as a %
1 + 1	100
3 + 3	94.29

Fuel saving achieved by test combination: 5.71%

Test 2

In test 2, the combination of tractor 2 and trailer 3 was compared with the control vehicle (tractor 1 and trailer 1). This test was conducted using the short route, on the B 28.

Test conditions:

Weather	Sunny
Wind speed	< 1.5 m/s
Temperature	13-16°C
Reference vehicle weight	39.67 t
Test vehicle weight	39.67 t
Speed	86 km/h

Results for test 2

Combination	Fuel consumption as a %
1 + 1	100
2 + 3	90.21

Fuel saving achieved by test combination: *9.79%*

Due to the significantly different tyres fitted to the standard-specification semi-trailers, the results of this test do not allow a direct comparison to be made between vehicles from the manufacturers Schmitz and Kögel (tests 3/3.1 and test 2)!

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Test 3

In test 3, the combination of tractor 3 and trailer 3 was compared with the control vehicle (tractor 1 and trailer 1). This test was conducted using the short route, on the B 28.

There was a difference in speed of 5 km/h between test and control vehicles. The control vehicle was driven at 90km/h and the test vehicle at 85 km/h, both on cruise control. The test was designed to show how higher speed increases aerodynamic and rolling resistance, and as a result fuel consumption. Because the consumption figures for test vehicle 1 were known from test 1, this test demonstrated that a 5 km/h increase in speed increased the baseline fuel consumption figure achieved with control vehicle.

Test conditions:

Weather	Sunny
Wind speed	< 1.5 m/s
Temperature	13°C
Reference vehicle weight	39.98 t
Test vehicle weight	39.98 t
Speed	85/90 km/h

Results for test 3

Combination	Fuel consumption as a %
1 + 1 (90 km/h)	100*
3 + 3 (85 km/h)	92.68

Fuel saving achieved at 85 km/h compared with 90 km/h: *7.32%*

*) Actual measured figures.

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Test 4

In test 4, tests have been conducted using similar trailers produced by different manufactures. Fuel consumption results are comparable and not relevant for the aim of this test. Therefore results are not published.

Test 4.1

In test 4.1, tests have been conducted using similar trailers produced by different manufactures. Fuel consumption results are comparable and not relevant for the aim of this test. Therefore results are not published.

Test 5

In test 5, tests have been conducted using similar trailers produced by different manufactures. Fuel consumption results are comparable and not relevant for the aim of this test. Therefore results are not published.

5) Test results

It was possible to demonstrate that the comparative measurement process produced sufficiently accurate results to support conclusions about the effect of technical changes to the tractor, semi-trailer or combination of the two on fuel consumption.

Test 1 showed that the modifications described in section 2.2 produce a fuel saving of 4.77% over a conventional articulated LGV.

Test 2 showed that further modifications as described in section 2.2 result in potential fuel savings of 9.79% compared with a conventional articulated LGV.

Tests 1 and 2 were both carried out using the same standard semi-trailers. In other words, the changes in fuel consumption were entirely attributable to the modifications made to the tractor.

Test 3 showed, by comparison with the results of test 1, how an increase in speed affects fuel consumption. A higher speed results in the vehicle using more fuel.

Langenau, 15 September 2010

Christian Egger
Officially recognized expert in motor vehicle traffic