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NORDIC VS. CENTRAL EUROPEAN VEHICLE CONFIGURATION; FUEL ECONOMY, EMISSIONS, VEHICLE OPERATING COSTS AND ROAD WEAR

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ABSTRACT

The paper includes, firstly, description of the Finnish Vehicle Motion Simulator, VEMOSIM, its principles, input and output data and analysis output data. Secondly, the paper gives among other the following results:
*The so-called Nordic Vehicle Configuration in Finland, Sweden and Norway (truck + trailer, gross mass 60 t and maximum length 25.25 m) is much more effective measured in the transport power (tkm/h) and energy consumption (fuel, l//100 tkm) and much more environmental friendly (emission amounts, g/tkm) than the Central European vehicle combinations (gross mass 40 t, maximum length 18.75 m). The payload of the Nordic vehicle configuration is approximately 42 t, but the one of the Central European is only approximately 25 t. Though the fuel consumption per the traffic product unit (vehicle*km) increases with the mass, but calculated per the transport product unit (ton*kilometer) it decreases remarkably as well as the emissions.*
These results and many more have been obtained by using the VEMOSIM together with digital road and street data, DIGIROAD. The VEMOSIM results have been validated with field measurements.
The VEMOSIM-DIGIROAD system will be the future tool for analysing effectively, fast and economically the effects of road and traffic conditions, traffic management, alternative routes, vehicle and engine characteristics, driving technique, etc. on the energy consumption, emission amounts, etc. of transport and traffic systems.
*The VEMOSIM is based on vehicle dynamics - on one of the basic laws of physics, namely Force = Mass * Acceleration (F = m*a).*
In the case of road traffic, input data of the VEMOSIM includes three data categories: 1) engine and vehicle data, 2) road data and 3) driving patterns. The principal engine data consist of engine maps for fuel consumption and different emission components.

INTRODUCTION

This paper deals with the comparison of the Nordic vehicle configuration (later NVC) and the Central European vehicle configuration (later CEVC). The comparison is made so that the comparison quantities are produced for the NVC and CEVC in the same conditions (on the same road sections in Finland).

The tool used in the calculations is a vehicle motion simulator VEMOSIM based on the dynamics. The VEMOSIM outputs directly the used time, the fuel consumption and the emissions by components for any vehicle type. The economical impacts are produced indirectly by using VEMOSIM results and unit prices.

In this case VEMOSIM it has been applied for the Nordic vehicle configuration and the Central European vehicle configuration on the selected road sections. A short description on VEMOSIM is given in Appendix of this paper.

There are two kinds of comparison quantities; physical and monetary. The both are related to the traffic product (vehicle kilometers) and to the transport product (ton kilometers). The physical quantities are: the used time, the fuel consumption, the emissions by components and the equivalent single axle loads (ESAL). The monetary quantities are: the variable and fixed vehicle operating costs.

The road sections included in the simulations represent two types of topography in Finland: flat (in Western coast of Finland) and hilly (in the Central Finland). The lengths of the road sections used in the simulations are 176 km and 142 km.

VEHICLE DIMENSIONS AND MASSES IN THE EU AND SOME OTHER COUNTRIES

Heavy duty vehicles for goods transport are different in the European countries. When there is question of long haulage transportation, in general, goods are not transported by single unit trucks (without trailers), but the transportation occurs with vehicle combinations. This means that trucks are equipped either with semi-trailers or with trailers. However, the regulations concerning the masses and dimensions of these vehicles in national transportation vary from country to country.

Vehicle dimensions

The dimensions are more homogeneous, because they have been harmonized within the EU with few exceptions, but the masses can be decided at the national level. A very common length for an articulated vehicle (truck + semi-trailer) is 16.5 m and for a road train (truck + trailer) is 18.75 m. In Finland the maximum length for all road trains is 25.25 m as well as in Sweden for module combinations. If the road train in Sweden is not a module combination, the maximum length is 24 m. In Norway (not a member state of the EU) the maximum length for a timber vehicle combination was earlier 22 m, but since 2002 Norway has adopted the Swedish system.

Maximum gross mass of a vehicle combination

The maximum gross mass of a vehicle combination is in general 40 tons in the Central European countries. Before the year of 2000 in Switzerland (not a member state of the EU) this was 28 t. In Denmark the maximum gross mass of a vehicle combination is 48 t and in the Netherlands 50 t as well as in Norway until 2002. In Finland the maximum gross mass for a road train is 60 t, if the combinations has at least 7 axles, 53 t with 6 axles at least, 44 t with 5 axles at least and 36 tons with 4 axles at least. For an articulated vehicle the maximum gross mass is 48 t.

In Sweden there is no separation between an articulated vehicle and a road train. The maximum gross mass is 60 t, but naturally the number of axles restricts that as well as in Finland. Since 2002 Norway has adopted the Swedish practice.

Nordic vehicle configuration

The solution utilized in Finland and Sweden is called here a NORDIC VEHICLE CONFIGURATION (NVC). Today the Netherlands and Belgium have adopted this concept for test purposes during three years. After this period we can see whether this will remain permanent in those countries. The proposal to adapt the NVC is under consideration in Norway.

The main idea in the Nordic Vehicle Configuration is to save energy, reduce emissions and decrease transportation costs. Also the road wear will be reduced, while a reduced vehicle fleet with increased loads can take care of the same transportation product (ton*kilometers) distributed on an increased number of rear axles, but a decreased number of equivalent axles.
The solution utilised in the Central European countries is called here a CENTRAL EUROPEAN VEHICLE CONFIGURATION (CEVC).

TYPE VEHICLES, TRANSPORTATION ROUTES AND DRIVING TECHNIQUE IN THE CASE STUDY

In this presentation some cases are studied. The fuel consumption and emissions have been analyzed by VEMOSIM, which is a computer simulation system for the motion of any road and rail vehicle. The simulation method has been validated by several field tests.
The calculations concerning the vehicle operation costs are based on the current cost and price level in Finland. and the road wear survey is based on the AASHO road tests started in the early 1960's in USA and continued later all over the world

Type vehicles

In order the comparison between the different vehicle types would be possible the load space in all cases is assumed to be a sheeted body. The rated engine power varies according to the vehicle size (313 kW to 390 kW), but the engines are different versions of the same engine base model CUMMINS N14, which belongs to EURO 2 emission class.

A very common vehicle type in Central Europe is an articulated vehicle (truck + semi-trailer) The truck has 2 axles and the semi-trailer has 3 axles. The semi-trailer has a triple bogie with single wheels at each axle. In Finland the gross mass of this vehicle combination can be 42 tons, but in Central Europe it is normally 40 tons. In this survey we select the gross mass of 40 tons for this vehicle type, and then the payload (load capacity) is 26 tons. The rated engine power is 313 kW (425 hp).

In those countries, where the gross mass is 48 to 50 tons a very common vehicle combination is a 3-axled truck with 3-axled trailer. In Finland the gross mass of this type vehicle is 53 tons. The payload is 37 tons. This is selected for the second type vehicle to be surveyed. The rated engine power is also 313 kW (425 hp).

In Finland and Sweden the most common combination is a 3-axled truck with a 4-axled trailer. Then the gross mass is 60 tons and the payload 42 tons. The rated engine power is 350 kW (475 hp). This is the third type vehicle.

So far the gross mass of 60 tons is the maximum, although the combination has more than 7 axles. This occurs in general in case of the length of 25.25 meters, because the turning rule requires 5 axles in the trailer. In order to utilize the full capacity of the axle masses the gross mass of this combination could be 68 tons (truck 26 tons and trailer 42 tons) and respectively the payload would be 48 tons. This is not yet legal, but it might be the next step in the future solutions. This is selected for the fourth type vehicle in this survey. The rated engine power is 390 kW (530 hp).

By using 4-axled or 5-axled trucks the number of axles in the combination can still be increased . With a 4-axled truck the combination has 9 axles and gross train mass could be 74 tons and the payload 53 tons. This is the fifth type vehicle and its rated engine power is 390 kW (530 hp)

The sixth type vehicle is a 5-axled truck (38 tons) and a 5-axled trailer (42 tons). The gross train mass is then 80 tons and the payload 59 tons. The rated engine power is 390 kW (530 hp), see table 1.

Transportation routes

Two test road sections have been selected. The first one is KOKKOLA-OULU on the coast of Western Finland, where the terrain is very flat, and the second one is TAMPERE-JYVÄSKYLÄ in the Central Finland, where the terrain is hilly. In this way the impacts of the terrain topography can be observed. Figure 1 shows the dependencies of the longitudinal gradient as the functions of the distances of the both test road sections.

Because the VEMOSIM is based on the laws of physics, its results are applicable on any route and road type in any country of the globe.

Driving technique

The legal speed for trucks is 80 km/h, but the speed limiter is set to approximately 90 km/h (89 km/h). The test drives are made here with two goal speeds 80 km/h and 90 km/h. On downward slopes, where the gravitation accelerates the vehicles the goal speed can be temporarily exceeded by 10 km/h before brakes are used. The accelerator pedal is then in the upward position and no fuel flow occurs. This is called "swinging".

The rated engine speed in all versions is 1900 r/min. A gear change down takes place, when the engine speed falls to 1100 r/min and up, when it reaches 1700 r/min. In changing down the whole step is used, but in changing up the splitter is used.

RESULTS OF THE CASE STUDY

Fuel consumption

When the vehicle size is increasing the fuel consumption calculated per driven distance unit [l/100 km] is also increasing. However, the net load is increasing also, and if the fuel consumption is calculated per transport product unit [ton kilometer], the fuel consumption is decreasing. In this survey there are two road sections. The one highway no 8 represents a flat terrain and the other highway no. 9 a hilly terrain. The results of the fuel consumption concerning direction A (north) are presented in Table 2.

Emissions

The emissions of nitrogen oxides, carbon monoxide, hydro carbons, particulate matters and carbon dioxide were also analyzed. The results concerning direction A (north) are presented in Table 3.

Vehicle operation costs

The vehicle operating costs can be divided into variable and fixed costs. The variable costs are:
- fuel costs
- lubricant costs
- repair & maintenance costs
- tyre costs

The fixed costs are:
- capital costs: depreciation and interest
- wages + overhead costs
- insurance costs
- motor vehicle tax
- administrative costs

Normally the vehicle operating costs [/km] or [/h] increase with the vehicle size. The purchasing price is higher (capital costs), and also wages, insurance costs and fixed taxes are higher. The variable operating costs [/km] increase also, and the most obvious example of this is the fuel consumption and thus the fuel costs. But there is also an indirect impact on other variable operating costs. All the factors that affect the fuel consumption affect the other cost components in the same way. In this study a linear relationship has been applied; so a certain relative change of the fuel consumption has been converted directly to the lubricant, repair & maintenance and tyre costs. This is called Wehner's principle.

In the examples presented here the driving product (mileage) per vehicle has been assumed to be 150 000 km/a and the operation time is respectively 3 000 h/a. The results are presented in Table 4 and in figures 2 and 3.

Impacts on road wear

Concerning the road wear attention must be paid to the number of equivalent axles in the vehicle combination and the net load size. The real axles of the vehicle are converted to the equivalent single axle loads (ESAL) according to the rules of the AASHO Road Test.
The unit of this quantity is a single axle of 10 tons with twin wheels, and the other types of axles or axle groups are converted to these units.

From the viewpoint of road wear the most "road friendly" vehicle is the one that has the maximum load per equivalent axle, or inversely when a certain amount of goods must be transported, the number of equivalent axles shall be minimized.

The characteristics of the type vehicles from the road wear viewpoint are seen in table 5.

CONCLUSIONS

General conclusion concerning the way of analysis

The Vehicle Motion Simulator VEMOSIM based on dynamics is an effective tool for analyzing impacts of the characteristics of the different vehicle configurations on the motion state, fuel consumption and emissions.

Conclusions concerning the Nordic Vehicle Configuration (NVC) vs. the Central European Vehicle Configuration (CEVC)

NVC is in many aspects superior to CEVC.

The transportation of goods in general by the Central European vehicle is approximately 30 % more expensive per the transport product unit [tkm] than by the Nordic vehicle.

The Central European articulated vehicle consumes approximately one quarter more fuel per the transport product unit [tkm] than the Nordic road train.

Respectively, carbon dioxide emissions are one quarter higher in the Central Europe than in the Nordic countries.

The Central European articulated vehicle generates approximately two thirds more nitrogen oxides per the transport product unit [tkm] than the Nordic road train.

The Central European articulated vehicle wears approximately two thirds more road pavement per the transport product unit [tkm] than the Nordic road train.

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Additionally several presentations at Finnish workshops and congresses as well as several articles in Finnish magazines.

TABLES & FIGURES

Table 1 Characteristics of the type vehicles studied

No.	*Configuration*	*Number of axles*			*Gross mass*	*Payload*	*Rated power*
		truck	*trailer*	*tot.*			
		#	*#*	*#*	*t*	*t*	*kW*
1	Truck + semi-trailer	2	3	5	40	26.3	313
2	Truck + trailer	3	3	6	53	36.5	313
3	Truck + trailer	3	4	7	60	41.7	350
4	Truck + trailer	3	5	8	68	48.3	390
5	Truck + trailer	4	5	9	74	52.9	390
6	Truck + trailer	5	5	10	80	58.9	390

Table 2. Fuel consumption of alternative vehicles by gross mass

GOAL SPEED 80 km/h

GROSS MASS	*PAYLOAD*	*ROAD*	*AVERAGE SPEED*	*FUEL CONSUMPTION*	
t	t		km/h	1/100 km	1/100 tkm
40	26.3	8A	80.09	38.93	1.48
40	26.3	9A	79.10	41.33	1.57
53	36.5	8A	79.85	44.73	1.23
53	36.5	9A	77.16	47.84	1.31
60	41.7	8A	79.87	49.74	1.19
60	41.7	9A	77.27	53.15	1.27
68	48.3	8A	79.75	52.44	1.09
68	48.3	9A	76.54	57.03	1.18
74	52.9	8A	79.56	55.46	1.05
74	52.9	9A	75.44	60.34	1.14
80	58.9	8A	79.37	58.54	.99
80	58.9	9A	74.14	63.65	1.08

GOAL SPEED 90 km/h

GROSS MASS	PAYLOAD	ROAD	AVERAGE SPEED	FUEL CONSUMPTION	
t	t		km/h	l/100 km	l/100 tkm
40	26.3	8A	89.93	42.59	1.62
40	26.3	9A	87.93	43.84	1.67
53	36.5	8A	89.48	47.92	1.31
53	36.5	9A	85.21	49.86	1.37
60	41.7	8A	89.57	52.35	1.26
60	41.7	9A	85.42	55.03	1.32
68	48.3	8A	89.31	55.81	1.16
68	48.3	9A	84.53	58.81	1.22
74	52.9	8A	89.00	58.82	1.11
74	52.9	9A	83.28	61.95	1.17
80	58.9	8A	88.75	61.82	1.05
80	58.9	9A	81.95	65.13	1.11

Table 3. Emissions of alternative vehicles by gross vehicle mass (GVM)

GOAL SPEED 80 km/h

GVM	LOAD	ROAD	AVERAGE SPEED	NOx		CO		HC		PM	
t	t		km/h	g/km	g/tkm	g/km	g/tkm	g/km	g/tkm	g/km	g/tkm
40	26.3	8A	80.09	22.21	.845	1.24	.047	.35	.013	.11	.004
40	26.3	9A	79.10	18.79	.715	1.19	.045	.30	.011	.11	.004
53	36.5	8A	79.85	23.91	.655	1.50	.041	.36	.010	.13	.003
53	36.5	9A	77.16	20.83	.571	1.19	.033	.33	.009	.12	.003
60	41.7	8A	79.87	21.05	.505	.78	.019	.44	.011	.19	.005
60	41.7	9A	77.27	20.06	.481	.80	.019	.45	.011	.18	.004
68	48.3	8A	79.75	23.97	.496	1.72	.036	.49	.010	.17	.004
68	48.3	9A	76.54	21.30	.441	1.18	.024	.47	.010	.18	.004
74	52.9	8A	79.56	25.23	.477	1.86	.035	.52	.010	.18	.003
74	52.9	9A	75.44	22.14	.419	1.21	.023	.49	.009	.19	.004
80	58.9	8A	79.37	26.23	.445	1.96	.033	.54	.009	.19	.003
80	58.9	9A	74.14	23.11	.392	1.25	.021	.51	.009	.20	.003

GOAL SPEED 90 km/h

GVM	LOAD	ROAD	AVERAGE SPEED	NOx		CO		HC		PM	
t	t		km/h	g/km	g/tkm	g/km	g/tkm	g/km	g/tkm	g/km	g/tkm
40	26.3	8A	89.93	25.53	.971	.88	.033	.37	.014	.10	.004
40	26.3	9A	87.93	20.68	.786	.83	.032	.32	.012	.11	.004
53	36.5	8A	89.48	27.32	.748	1.03	.028	.38	.011	.12	.003
53	36.5	9A	85.21	21.45	.588	.96	.026	.33	.009	.12	.003
60	41.7	8A	89.57	25.70	.616	.69	.017	.49	.012	.15	.004
60	41.7	9A	85.42	21.81	.523	.76	.018	.45	.011	.17	.004
68	48.3	8A	89.31	26.03	.539	1.15	.024	.53	.011	.16	.003
68	48.3	9A	84.53	22.04	.456	.98	.020	.49	.010	.18	.004
74	52.9	8A	89.00	26.75	.506	1.22	.023	.55	.010	.17	.003
74	52.9	9A	83.28	23.09	.437	.99	.019	.51	.010	.18	.003
80	58.9	8A	88.75	27.39	.465	1.26	.021	.57	.010	.18	.003
80	58.9	9A	81.95	24.11	.409	1.03	.017	.53	.009	.19	.003

Table 4. The vehicle operating costs for type vehicles are the following:

PRESENT VEHICLES

	TYPE VEHICLE 1 40 t 5 axles			TYPE VEHICLE 2 53 t 6 axles			TYPE VEHICLE 3 60 t 7 axles		
	€/a	€/km	€/tkm	€/a	€/km	€/tkm	€/a	€/km	€/tkm
FUEL	41625	.278	.0105	48361	.322	.0088	51912	.346	.0083
LUBRICANT	1303	.009	.0003	1650	.011	.0003	1771	.012	.0003
REPAIR&MAINT.	16413	.109	.0042	17620	.117	.0032	18913	.126	.0030
TYRES	10068	.067	.0026	10004	.067	.0018	12691	.085	.0020
VARIABLE	69409	.463	.0176	77636	.518	.0142	85288	.569	.0136
DEPRECIATION	20038	.134	.0051	28028	.187	.0051	28988	.193	.0046
INTEREST	6012	.040	.0015	8408	.056	.0015	8696	.058	.0014
WAGES	45791	.305	.0116	48046	.320	.0088	48046	.320	.0077
INSURANCES	4710	.031	.0012	6730	.045	.0012	6730	.045	.0011

MOTOR VEH. TAX	1544	.010	.0004	2361	.016	.0004	2361	.016	.0004
FIXED	78095	.521	.0198	93573	.624	.0171	94822	.632	.0151
TOTAL	147505	.983	.0374	171209	1.141	.0313	180109	1.201	.0288

FUTURE VEHICLES

	TYPE VEHICLE 4 68 t 8 axles			*TYPE VEHICLE 5 74 t 9 axles*			*TYPE VEHICLE 6 80 t 10 axles*		
	€/a	**€/km**	**€/tkm**	**€/a**	**€/km**	**€/tkm**	**€/a**	**€/km**	**€/tkm**
FUEL	55678	.371	.0077	58409	.389	.0074	60675	.404	.0069
LUBRICANT	1900	.013	.0003	1993	.013	.0003	2071	.014	.0002
REPAIR&MAINT.	20286	.135	.0028	21280	.142	.0027	22106	.147	.0025
TYRES	15707	.105	.0022	17575	.117	.0022	19398	.129	.0022
VARIABLE	93570	.624	.0129	99258	.662	.0125	104249	.695	.0118
DEPRECIATION	29949	.200	.0041	32332	.216	.0041	34715	.231	.0039
INTEREST	8985	.060	.0012	9700	.065	.0012	10415	.069	.0012
WAGES	48046	.320	.0066	48046	.320	.0061	48046	.320	.0054
INSURANCES	6730	.045	.0009	6730	.045	.0008	6730	.045	.0008
MOTOR VEH. TAX	2361	.016	.0003	2906	.019	.0004	3451	.023	.0004
FIXED	96070	.640	.0133	99714	.665	.0126	103357	.689	.0117
TOTAL	189641	1.264	.0262	198971	1.326	.0251	207606	1.384	.0235

Table 5. Characteristics of the type vehicles from the road wear viewpoint

#	*Gross mass*	*Net load*	*# axles*	*# equivalent axles*	*Net load/eq. axle*	*Index*
	t	*t*			*t/eq. axle*	
1	40	26.3	5	3.30	7.93	166
2	53	36.5	6	3.34	10.89	121
3	60	41.7	7	3.15	13.19	100
4	68	48.3	8	3.44	13.98	94
5	74	52.9	9	3.82	13.82	95
6	80	58.9	10	3.88	15.15	87

FIGURE 1. TEST ROAD SECTIONS: GRADIENT VS. DISTANCE

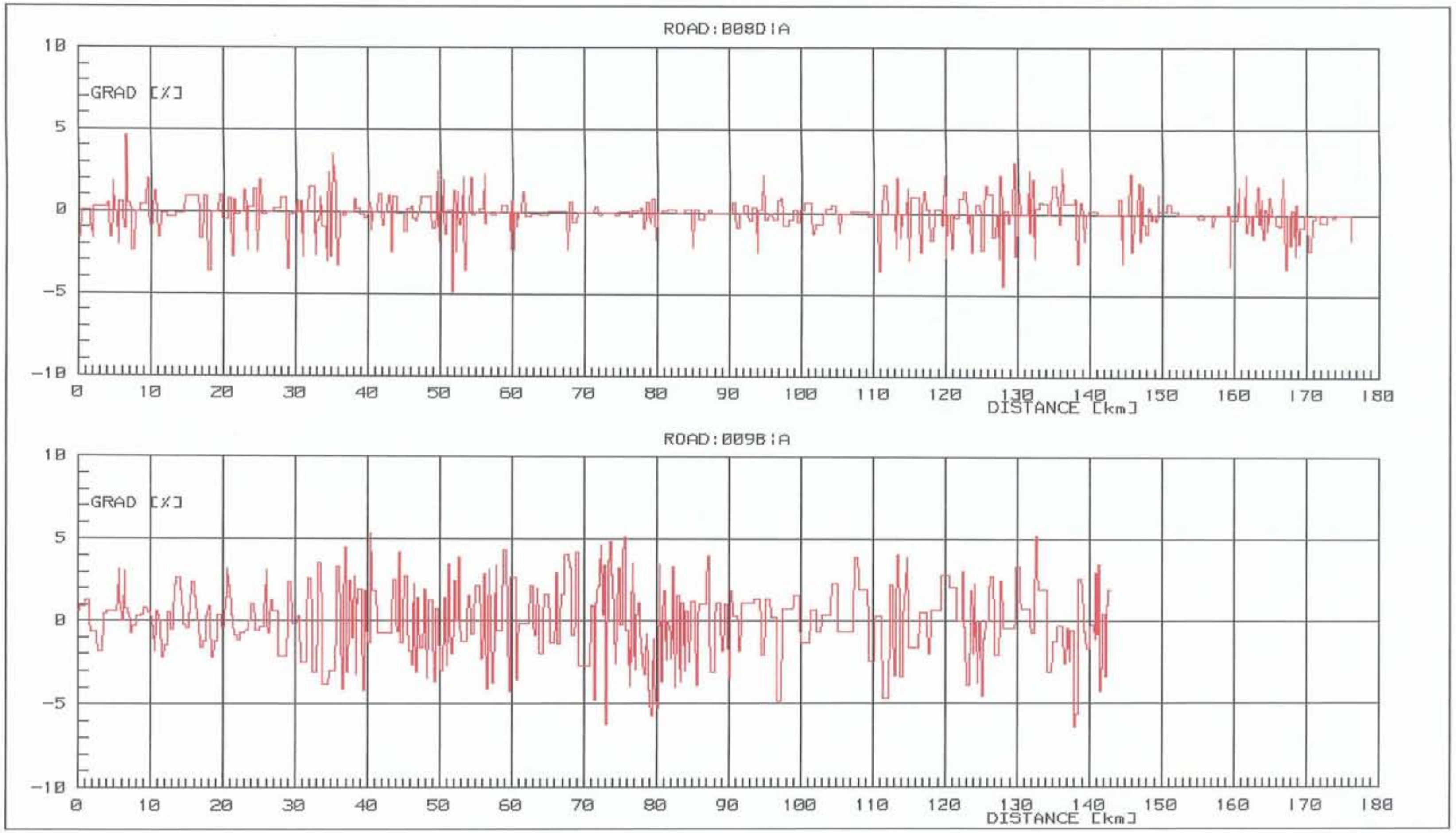


FIGURE 2. OPERATING COSTS VS. GROSS MASS OF DIFFERENT VEHICLE TYPES

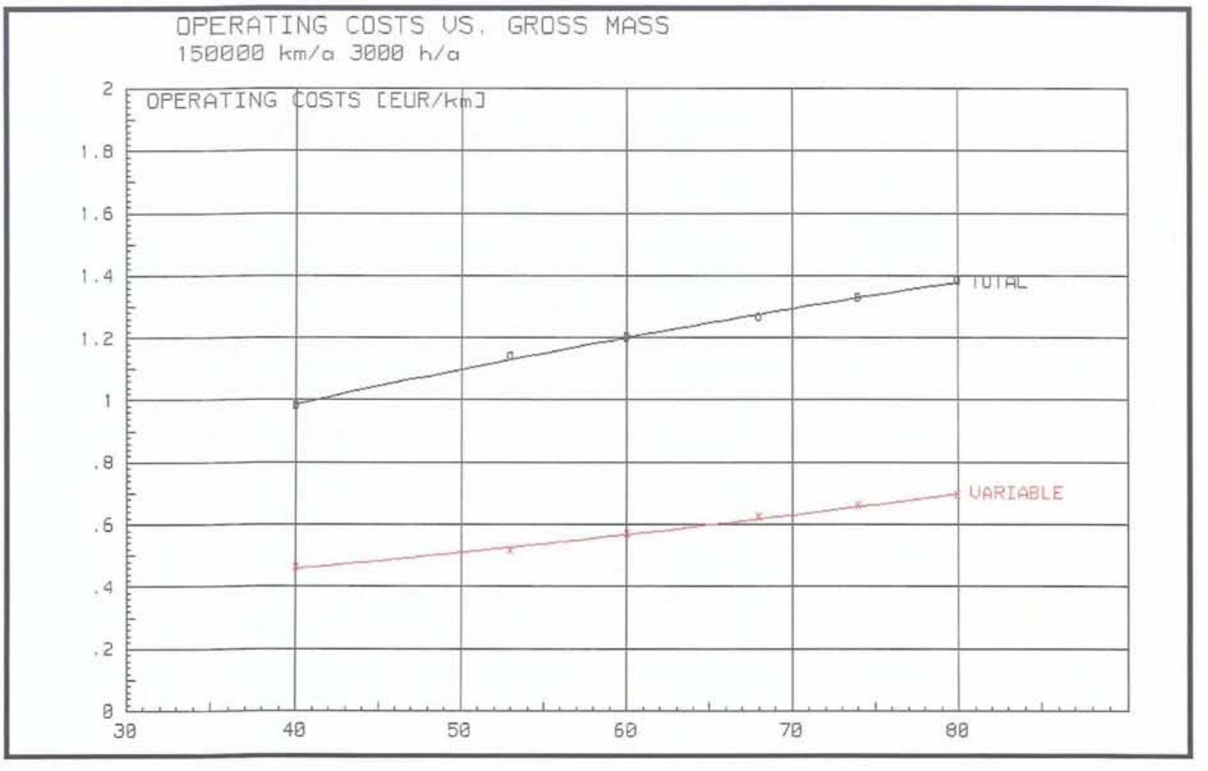
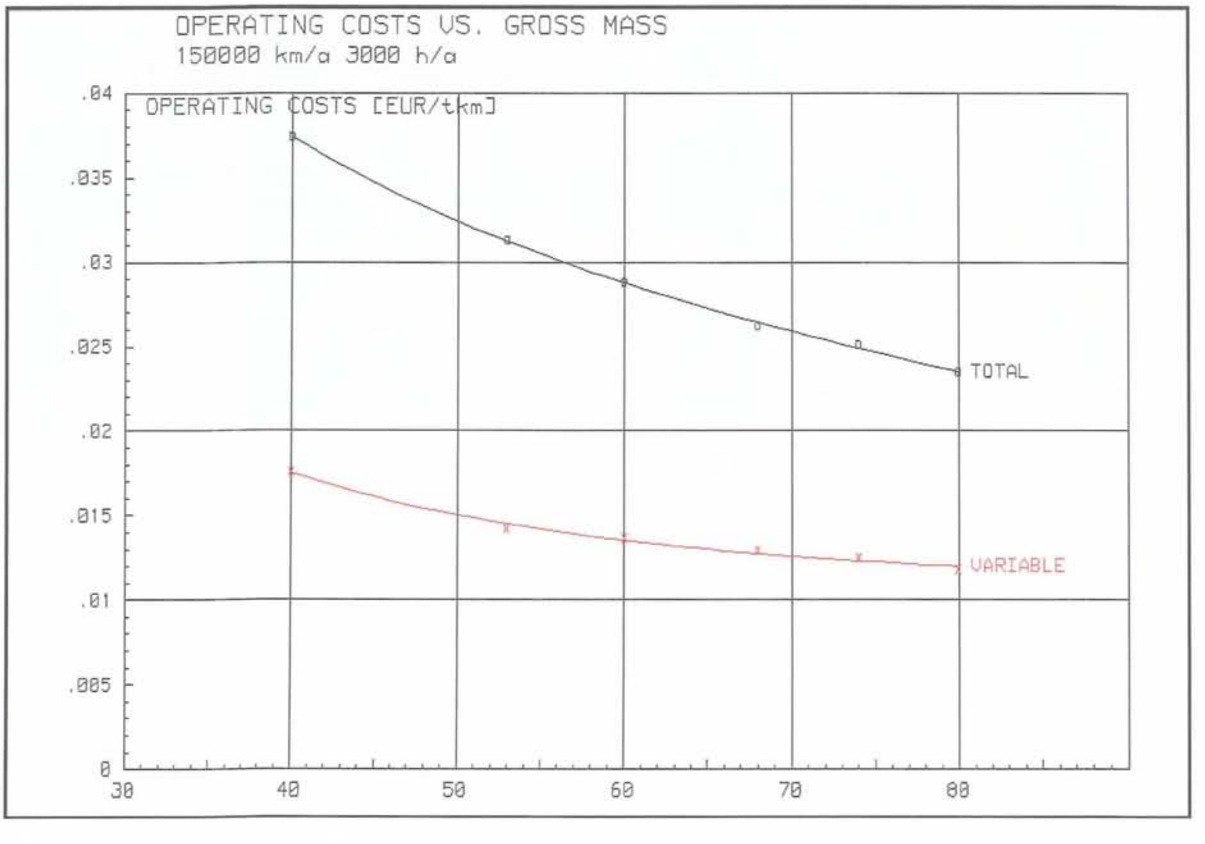


FIGURE 3. OPERATING COSTS PER TON KILOMETER VS. GROSS MASS OF DIFFERENT VEHICLE TYPES



Appendix
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VEHICLE MOTION SIMULATOR (VEMOSIM)

INTRODUCTION

The vehicle computer simulation system has been developed by Mr. Olavi H. Koskinen in the Ministry of Transport and Communications in Finland in order to simulate the motion of a real vehicle in normal road and traffic conditions. In that simulation process the vehicle can be driven either in undisturbed or disturbed traffic flow according to predefined driving techniques and rules (goal speed, schwung, use of gears etc). The simulation output can be continuous, so also the statistical analysis of the drive containing the elapsed time, proceeded distance, consumed fuel amount, use of gears, engine power, torque, engine load distribution etc.

SIMULATION SYSTEM IN DETAIL

The technical characteristics of the vehicle and road must be given as input data, before the simulation process can be started. The idea of the simulation is simply based upon the Newton's second law, which is expressed in the following differential equation:

$$m\, dv/dt = F_t - F_r$$

where:

v = vehicle speed
t = time
m = vehicle mass
F_t = traction force
F_r = resistance force

The current resistance force (F_r) is determined by the drive resistance parameters of the vehicle (rolling and air resistance coefficients) and current longitudinal road gradient. The traction force (F_t) is regulated by using the accelerator and brake pedals and various gears.

The geometric data of the road are stored in a very compact mode as distance-altitude or respectively as distance-gradient coordinates. In the former case the rounding curves between them are determined by an effective iterative algorithm.

The vehicle data for the computer simulation are:

- drive resistance coefficients
- description of the power train
- description of the engine
  - maximum torque as a function of the engine speed
  - fuel flow rate as a function of the engine speed and torque (engine map of fuel consumption)
  - emission flow rates by components (NO_x, CO, HC, PM, CO_2) as functions of the engine speed and torque

The quantities, which are followed continuously in the standard output during the drive, are:

- time
- proceeded distance
- consumed fuel amount
- emission amounts if available and selected
- gear position
- current speed
- current engine speed
- longitudinal road gradient

- position of accelerator pedal
- current engine power
- engine load degree
- traction force
- resistance force
- brake force

In the graphical output it is possible to plot several different quantities. The standard graphical output contains, as a function of the distance, the current speed, the cumulative fuel amount or the current fuel consumption per distance unit [l/100 km] and the longitudinal road gradient. In addition, the locations of the gear changes are plotted in the figure; changes up and down with different symbols.

The drive can be analyzed. There are two options, short and long. The long analysis prints the following information:

- time of drive
- distance of drive
- average speed
- cumulative rotation angle of engine
- average engine speed
- loading distribution of engine
  - time distribution by engine speed and torque categories
  - distance distribution by engine speed and torque categories
- drive at full load (maximum torque): time and distance
- average power, torque and loading degree of engine
- fuel consumption
  - time, distance and fuel amount distribution by specific fuel consumption categories
  - consumed fuel amount
  - average fuel consumption per distance, per time and average specific fuel consumption
- emission amounts if available and selected for survey
- use of brakes: time and distance
- use of gears
  - drive at different gears: time, distance and average speed
  - number of gear changes: down, up, to neutral
- time and distance distribution by different speed and acceleration categories
- drive work: engine work, traction work, resistance work, brake work, acceleration work and average thermal efficiency

EMISSION SIMULATION

If emission maps of different pollutants are available, the impact of the environmental pollution can be studied by this simulation system in various road and traffic conditions. However, for the time being there is a lack of emission maps of engines and they are not easily available from the engine manufacturers.

Therefore the COST 346 project was started in 1999 from the initiative of Finland and supported by Sweden to produce engine maps including also emissions from heavy duty vehicles.