EXTERNAL COSTS OF TRANSPORT

UPDATE STUDY

Final Report
Zurich/Karlsruhe, October 2004

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OVERVIEW

CONTENT

SUMMARY

AIM AND METHODOLOGY

This study is an update of a former UIC study on external effects (INFRAS/IWW 2000). It aims at improving the empirical basis of external costs of transport based on the actual state of the art of cost estimation methodologies reflecting also recent studies on external costs of transport on a European level (especially UNITE).

The following dimensions are considered:

- Cost categories: Accidents, noise, air pollution (health, material damages and biosphere), climate change risks, costs for nature and landscape, additional costs in urban areas, up- and downstream processes and congestion.
- Countries: EU 17 (EU member states, Switzerland, Norway).
- Base year: Detailed results for 2000.
- Differentiation by means of transport:
    - Road transport: Private car, motorcycles, bus, light goods vehicles, heavy goods vehicles,
    - Rail transport: Passenger and freight,
    - Air transport: Passenger and freight,
    - Waterborne transport: Inland water transport (freight).

Two study outputs can be distinguished:

- Total and average costs for EU17 differentiated by means of transport,
- Marginal costs per means of transport and traffic situation reflect the additional costs per additional unit of transport. They represent a European average which could be used as basis for the dimensioning of pricing instruments according to the approach of Social Marginal Cost Pricing.

The following table summarises the approach with respect to INFRAS/IWW (2000)

SUMMARY OF METHODOLOGY FOR EACH COST COMPONENT			
Cost component (% of total costs)	**Approach**	**Data basis**	**Differences to the past study**
Accident costs (24%)	Same approach as in INFRAS/IWW 2000	IRTAD, UIC, EUROSTAT statistics	Estimations based on the monitoring/victims principle
Noise costs (7%)	Same approach as in INFRAS/IWW 2000, improved database and methodology for Germany as reference country	ECMT, OECD, STAIRRS (railway noise), UBA Germany	New values for valuation of mortality impacts of transport noise
Air pollution (27%)	Same approach as in INFRAS/IWW 2000	Updated TRENDS data for emissions and traffic volumes, improved emission factors	Improved data basis for emissions, latest results for non exhaust emissions of PM10
Climate change (30%, high scenario)	Same approach as in INFRAS/IWW 2000 (avoidance costs)	TRENDS data for emissions, new shadow prices, two Scenarios: € 20 (low) and € 140 (high) per tonne CO2	New data on avoidance costs and related shadow prices
Costs for nature and landscape (3%)	Same approach as in INFRAS/IWW 2000 (unsealing, restoration and renaturation costs)	EUROSTAT, New Swiss study on costs of nature and landscape (methodology)	Very small differences (mainly changes of transport infrastructure network).
Additional costs in urban areas (2%)	Same approach as in INFRAS/IWW 2000	Up-to-date population data for cities and urban areas	Up-to-date population figures for cities and urban areas, adaptation of cost indicators according to GDP per capita
Up- and downstream processes (7%)	Same approach as in INFRAS/IWW 2000	Ecoinvent, Ecoinventory for the transport sector	Up-to-date life cycle assessment data based on Ecoinvent 2003.
Congestion costs (separate cost category)	Same approach as in INFRAS/IWW 2000	European Transport Model VACLAV	Use of a new traffic data base which is consistent for all countries

Table 1 Remark: The percentages reflect the share of total costs excluding congestion costs.

As shown in Table 1 we use a similar methodological approach to the past study INFRAS/IWW (2000) for this update study. The main reason for this updating procedure is to allow comparability between both studies. The methodology will be applied on significantly improved and updated data sets of most input parameters (e.g. traffic volumes, emission data, dose-response functions, etc.).

Throughout the whole report, congestion costs are treated as a separate issue, since their relevance and measurement are quite different from the ones of other costs categories, especially in regard to total costs. While all other cost categories considered in this study reflect the external costs imposed by transport on the whole of society, including inhabitants not participating in transport, congestion is a phenomenon within the transport sector. Therefore, congestion costs must not be added up with classical externalities.

Three different measures are presented; they provide different results from 0.7% of GDP (deadweight loss as the potential welfare increase when congestion is internalised) to 8.4% of GDP (sum of charges to be raised to internalise congestion costs) as they address entirely different aspects of the congestion problem. The deadweight loss is taken as the economic measure of external congestion costs in this study.

TOTAL AND AVERAGE COSTS

Accident and environmental costs 2000

The following figures present the results for total and average costs for 2000. **Total external costs** (excluding congestion costs, with climate change high scenario) amount to 650 billion € for 2000, being 7.3% of the total GDP in EU 17. Climate change is the most important cost category with 30% of total cost, if high shadow prices are used. Air pollution and accident costs amount to 27% and 24% respectively. The costs for noise and up- and downstream processes each account for 7% of total costs. The costs for nature and landscape and additional urban effects are of minor importance (5%). The most important mode is road transport, causing 83.7% of total cost, followed by air transport, causing 14% of total external costs. Railways (1.9%) and waterways (0.4%) are of minor importance. Two thirds of the costs are caused by passenger transport and one third by freight transport.

TOTAL COSTS IN 2000 BY COST CATEGORY & TRANSPORT MODE													
[million Euro/year]			**Road**							**Rail**		**Aviation**		**Water-borne**
	Total	%	Car	Bus	MC	LDV	HDV	Pass. total	Freight total	Pass.	Freight	Pass.	Freight	Freight
Accidents	156'439	24	114'191	965	21'238	8'229	10'964	136'394	19'194	262	0	590	0	0
Noise	45'644	7	19'220	510	1'804	7'613	11'264	21'533	18'877	1'354	782	2'903	195	0
Air Pollution	174'617	27	46'721	8'290	433	20'431	88'407	55'444	108'838	2'351	2'096	3'875	360	1'652
Climate Change High	195'714	30	64'812	3'341	1'319	13'493	29'418	69'472	42'911	2'094	800	74'493	5'438	506
Climate Change Low [1)]	*(27'959)*	*(4)*	*(9'259)*	*(477)*	*(188)*	*(1'928)*	*(4203)*	*(9'925)*	*(6'130)*	*(299)*	*(114)*	*(10'642)*	*(777)*	*(72)*
Nature & Landscape	20'014	3	10'596	276	233	2'562	4'692	11'105	7'254	202	64	1'211	87	91
Up-/Downstream [2)]	47'376	7	19'319	1'585	335	5'276	16'967	21'240	22'243	1'140	608	1'592	170	383
Urban Effects	10'472	2	5'782	147	127	1'220	2'634	6'112	3'797	426	137	0	0	0
Total EU17 [3)]	650'275	100	280'640	15'114	25'491	58'824	164'346	321'301	223'114	7'828	4'487	84'664	6'250	2'632

Table 2 Total external costs of transport in the EU17 countries.
Remarks:
1) Climate change costs for the climate change low scenario with a shadow value of 20€/ t CO_2 (for information only, values not used to calculate total costs).
2) Climate change costs of up- and downstream processes are calculated with the shadow value of the climate change high scenario (140€/t CO_2).
3) Total costs calculated with the climate change high scenario.

TOTAL EXTERNAL COSTS 2000 (EXCLUDING CONGESTION)

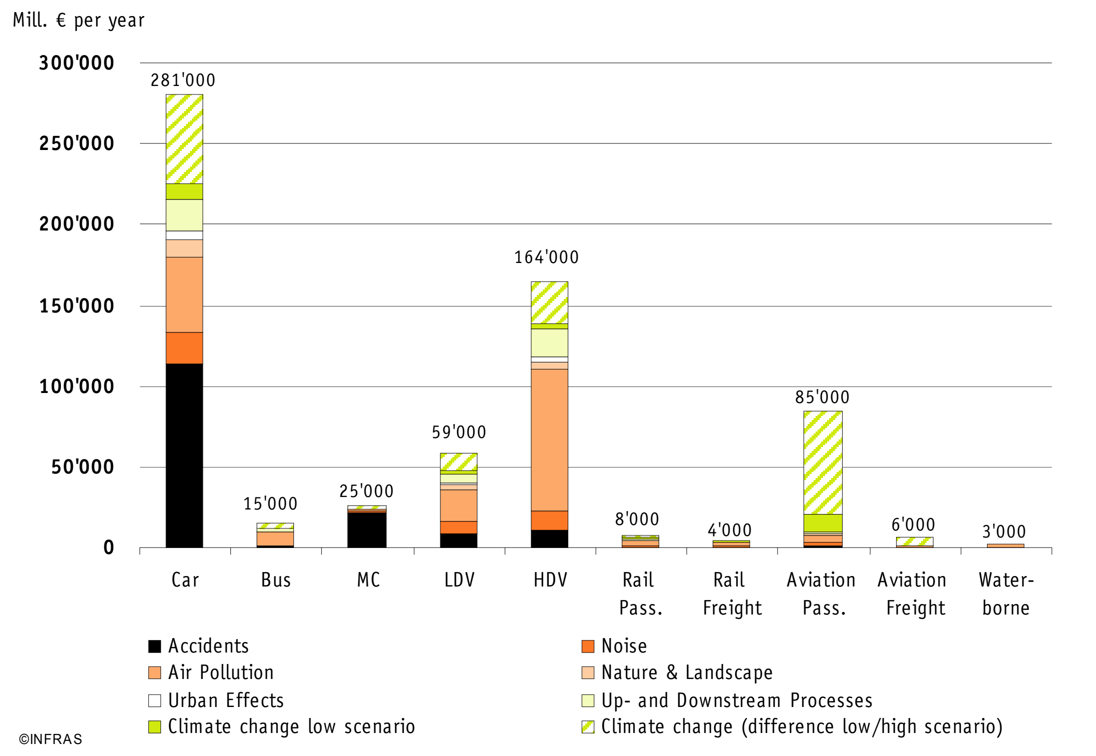

Figure 1 Total external costs 2000 (EU 17) by means of transport and cost category. Road transport is responsible for 84% of total external costs.

Average costs are expressed in Euro per 1'000 pkm and tkm. Within the passenger transportation sector, passenger cars reach 76 Euro (high scenario). Railway costs amount to 22.9 Euro, which is 3.3 times lower than costs for the road sector. Most important for the railway sector are the effects on air pollution, climate change and noise. For the aviation sector, the predominant cost category is climate change.

In the freight sector, the average costs of air transport are significantly higher than the costs of all other means of transport. This is especially due to the fact that freight load (in tonnes) differs from mode to mode. Aeroplanes for example transport high quality freight of low specific weight. The costs for HDV (heavy duty vehicles) amount to 71.2 Euro per 1'000 tkm, which is 4 times higher than the cost for railways (Climate change high scenario).

AVERAGE COSTS IN 2000 BY COST CATEGORY & TRANSPORT MODE														
	Average Cost Passenger							Average Cost Freight						
	Road				Rail	Avia-tion	Over-all	Road			Rail	Avia-tion	Water-borne	Over-all
	Car	Bus	MC	Pass. total				LDV	HDV	Total				
	[Euro / 1000 pkm]							[Euro / 1000 tkm]						
Accidents	30.9	2.4	188.6	32.4	0.8	0.4	22.3	35.0	4.8	7.6	0.0	0.0	0.0	6.5
Noise [1)]	5.2	1.3	16.0	5.1	3.9	1.8	4.2	32.4	4.9	7.4	3.2	8.9	0.0	7.1
Air Pollution	12.7	20.7	3.8	13.2	6.9	2.4	10.0	86.9	38.3	42.8	8.3	15.6	14.1	38.5
Climate Change High	17.6	8.3	11.7	16.5	6.2	46.2	23.7	57.4	12.8	16.9	3.2	235.7	4.3	16.9
Climate Change Low[2)]	*(2.5)*	*(1.2)*	*(1.7)*	*(2.4)*	*(0.9)*	*(6.6)*	*(3.4)*	*(8.2)*	*(1.8)*	*(2.4)*	*(0.5)*	*(33.7)*	*(0.6)*	*(2.4)*
Nature & Landscape	2.9	0.7	2.1	2.6	0.6	0.8	2.0	10.9	2.0	2.9	0.3	3.8	0.8	2.6
Up-/Down-stream [3)]	5.2	3.9	3.0	5.0	3.4	1.0	3.9	22.4	7.4	8.8	2.4	7.4	3.3	8.0
Urban Effects	1.6	0.4	1.1	1.5	1.3	0.0	1.1	5.2	1.1	1.5	0.5	0.0	0.0	1.3
Total EU 17[4)]	76.0	37.7	226.3	76.4	22.9	52.5	67.2	250.2	71.2	87.8	17.9	271.3	22.5	80.9

Table 3 Average external costs of transport in the EU17 countries
Remarks:
1) The modal differences in noise costs are directly related to the national noise exposure databases used and thus might be subject to different ways of noise exposure measurement.
2) Average climate change costs for the low scenario (for information only, values not used to calculate total costs))
3) Climate change costs of up- and downstream processes are calculated with the shadow value of the 'Climate Change High Scenario'
4) Total average costs calculated with the climate change high scenario.
5) Noise costs for freight trains might be under-estimated as the simplified traffic allocation procedure applied did allocate most freight trains to daytime traffic.

AVERAGE EXTERNAL COSTS: PASSENGER 2000 (EXCLUDING CONGESTION)

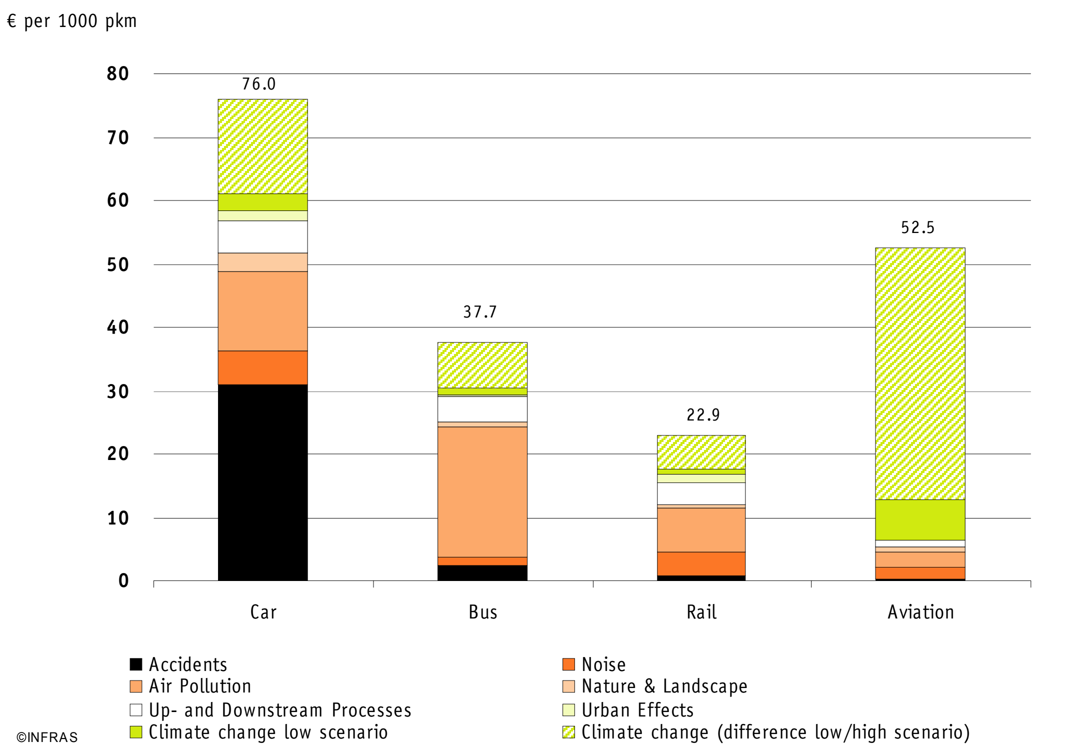

Figure 2 Average external costs 2000 (EU 17) by means of transport and cost category: Passenger transport. The high value of climate change costs in aviation is due to the higher global warming effect of aviation's CO_2 emissions at high altitude during flight (factor 2.5 used compared to the impacts of CO_2 emissions on the earth surface, based on IPCC 1999).

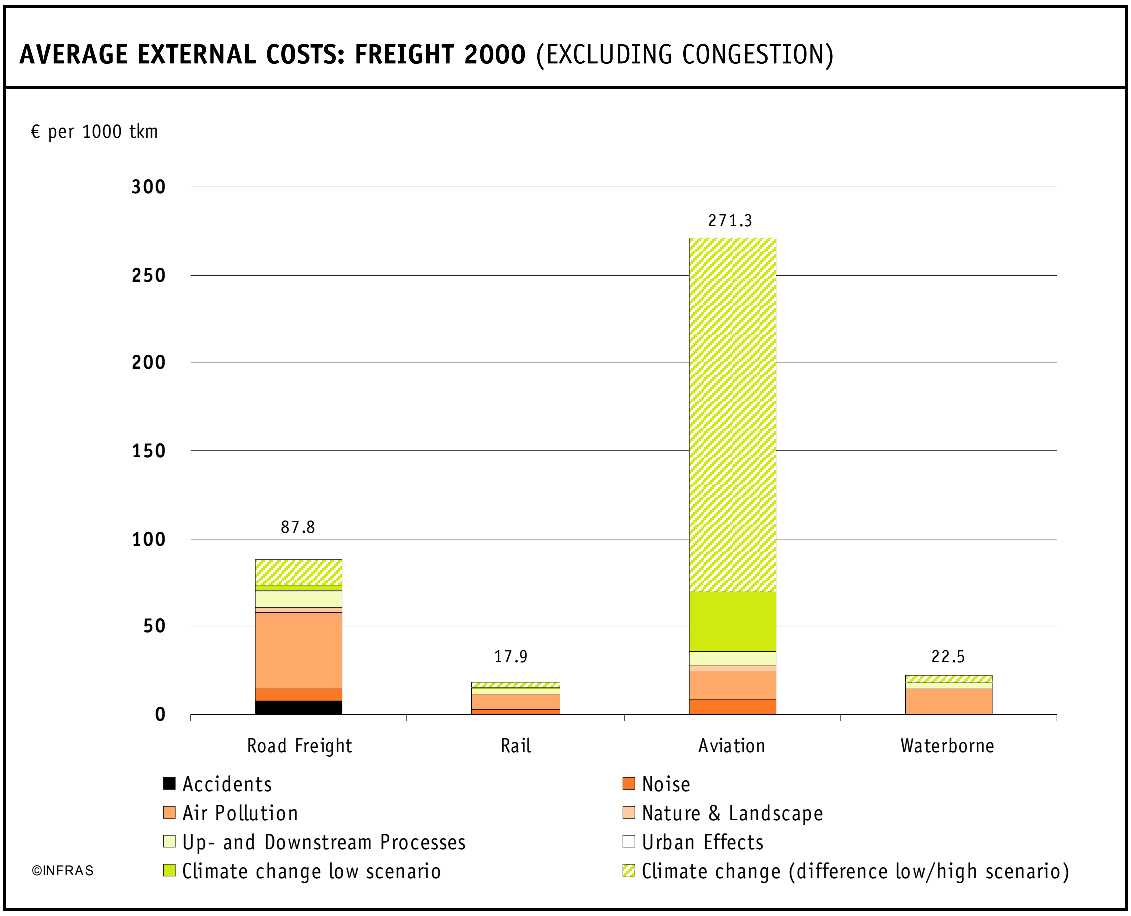

Figure 3 Average external costs 2000 (EU 17) by transport means and cost category: Freight transport. The high value of climate change costs in aviation are due to the higher global warming effect of aviation's CO_2 emissions at high altitude during flight (factor 2.5 used compared to the impacts of CO_2 emissions on the earth surface, based on IPCC 1999).

Development 1995–2000

Total costs increase in the period 1995–2000 by 12.1% (1995 values adjusted to 2000 prices). The main reason for this development are increasing traffic volumes which lead to higher green house gas emissions and thus to increasing climate change risks (especially in road passenger transport and air passenger transport). Another cost category which shows increasing costs are air pollution costs especially for road freight transport. Although PM10 exhaust emissions decrease significantly due to improved engine technologies and particle filters, non exhaust emissions increase more or less in line with traffic volumes.

COMPARISON: TOTAL EXTERNAL COSTS 1995 AND 2000 (EXCLUDING CONGESTION)

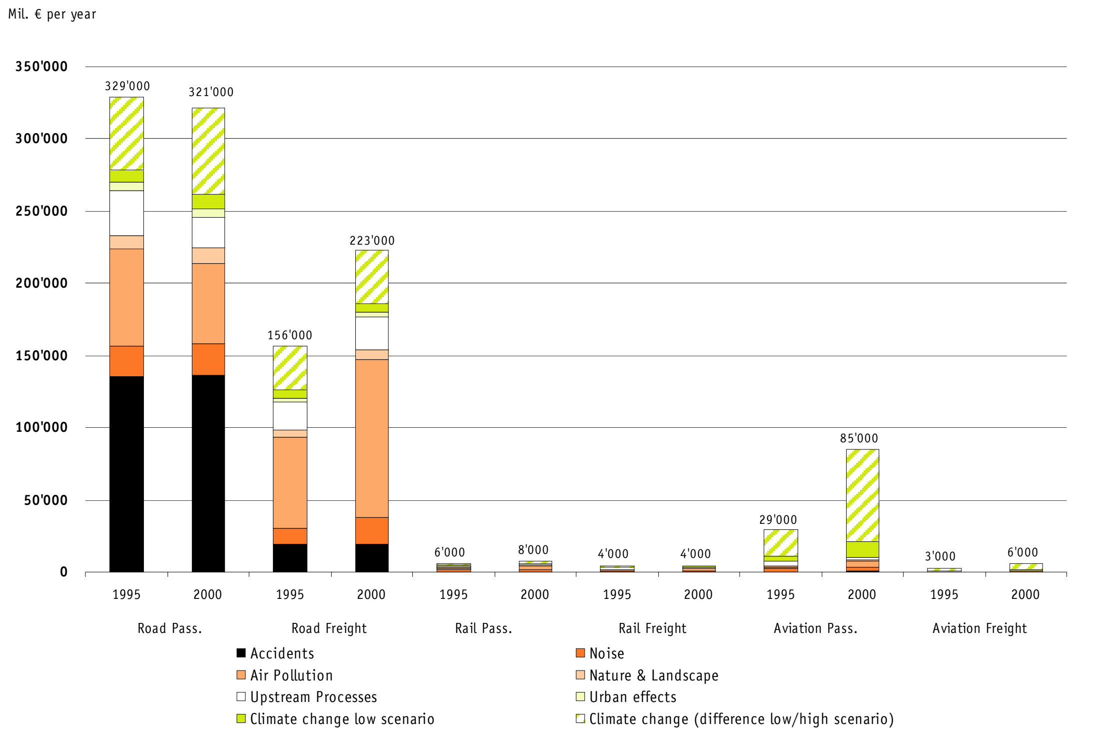

Figure 4 Comparison with the total external costs between the years 1995 and 2000 by transport means and cost category (1995 values at 1995 prices, 2000 values at 2000 prices).

MARGINAL COSTS

The following table shows the values (the ranges respectively) for all cost categories. The ranges are quite significant, since different vehicle categories, countries and traffic situations are considered.

AGGREGATED RESULTS: MARGINAL COSTS												
€/1000 pkm/tkm		Road					Rail		Aviation		Waterborne
		Car	Bus	MC	LDV	HDV	Pass.	Freight	Pass.	Freight	Freight
Accidents	Marginal	10-90	1-7	36-629	10-110	0.7-11.8	-	-	-	-	-
	Average	30.9	2.4	188.6	35.01	4.75	0.74	-	0.37	-	0
Noise [1]	Marginal	0.07-13	0.05-4.6	0.25-33	2.4-307	0.25-32	0.09-1.6	0.06-1.08	0.1-4.0	0.3-19	0
	Average	5.2	1.3	16.0	32.4	4.9	3.9	3.2	1.8	8.9	0.00
Air Pollution	Marginal	5.7-44.9	12-18	3.2	15-100	33.5	5.1	7.4	0.2	1.8	8.8
(only health costs)	Average	10.1	16.9	3.3	77.6	34.0	5.1	7.4	0.2	1.8	8.8
Climate Change	Marginal	1.7-27	0.7-9.5	1.7-11.7	8.2-57.4	1.8-12.8	0.3-7.1	0.4-5.3	6.6-46.2	33.7-235.7	4.3
	Average	17.6	8.3	11.7	57.4	12.8	5.9	3.2	46.2	235.7	4.3
Nature & Landscape	Marginal	0-2.1	0-1.3	1.9	10.9	0.8	0.7-1.2	0.1	1.1	6.5	0.8
	Average	2.87	0.69	2.07	10.90	2.03	0.58	0.26	0.75	3.77	0.78
Urban effects	Marginal	1.1-9.6	0.1-2.2	0.7-7.1	3.0-32.3	0.9-7.1	0	0	0	0	0
	Average	1.6	0.4	1.1	5.2	1.1	1.3	0.5	0	0	0
Up- and down-	Marginal	2.0-4.1	2.6-6.0	1.3-2.7	13.0-23.4	3.6-7.4	0.9-8.3	0.2-1.7	0.8-0.9	6.3-8.1	0.8-1.8
stream processes	Average	5.2	3.95	2.98	22.44	7.36	3.22	2.44	0.99	7.38	3.27

Table 4 Marginal costs by cost category and transport mean (the ranges reflect different vehicle categories (petrol, diesel, electricity) and traffic situations (urban, interurban). For urban effects ranges show different marginal costs of space availability and (low values) and separation costs (high values). For comparison average values as shown in chapter 3 are presented for each cost category**.**
Remarks:
1) Average and marginal noise costs are measured by different methods and thus are not fully comparable. The marginal values are to be understood as ranges of usual costs. Considerably higher or lower values are possible in particular cases.

If we compare average to marginal costs, the following general conclusions can be drawn:

› The level of marginal and average cost is comparable. Marginal costs are much more differentiated, since they relate to different traffic situations and types of vehicles.
› Most important for the order of magnitude of marginal accident costs are the assumptions concerning the level of internalisation of the accident risk.

- Due to their decreasing cost function marginal noise costs fall below average costs for medium to high traffic volumes. However, in road and air traffic they may exceed average costs since roads frequently lead through settlements and the alternation of traffic loads over day vary considerably between the modes. The same holds for airports, where approach paths often lead directly over housing areas.
- For air pollution, average values are basically similar to marginal values due to linear dose response functions and model calculations. There are big differences between different vehicle categories.
- For climate change, average costs are equal to marginal costs. The ranges stem from different vehicle categories. The same low-high assumptions are applied.
- For nature and landscape, average costs are close to maximum marginal costs. This is plausible since marginal costs are mostly not relevant in the short run.
- Marginal costs of urban effects are generally higher than average costs. Both values should be compared carefully since marginal costs are calculated using only urban traffic volumes while average costs are calculated with national traffic volumes. Marginal separation costs are significantly higher than marginal space availability costs.
- For up- and downstream processes marginal costs are mainly related to precombustion processes. Therefore marginal costs are generally lower than average costs which include as well vehicle and infrastructure related processes (production, maintenance and disposal of rolling stock and infrastructure). Thus average costs are close to long run marginal costs.

CONGESTION COSTS

Total congestion costs are defined according to economic welfare theory by the deadweight loss measure, which represents the costs arising from an inefficient use of the existing infrastructure. For the EUR-17 countries, total and average road congestion costs, revenues expected from their internalisation via road pricing systems and an "engineering" measure of additional time costs have been estimated for the year 2000. Due to the chosen welfare-economic approach, congestion costs by definition only appear for transport modes where single users decide on the use they make of infrastructure. Consequently, rail and air traffic are not affected by this kind of congestion. A comparison of the three congestion-related approaches is presented by the following figure.

DEADWEIGHT LOSS, CHARGING REVENUES AND DELAY COSTS IN ROAD TRANSPORT 2000

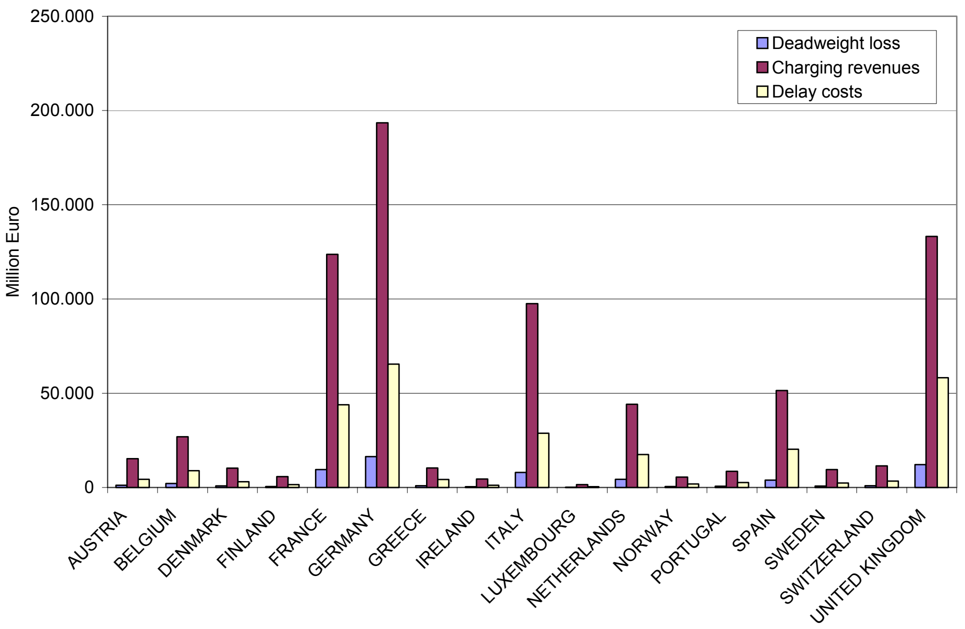

Figure 5 Comparison of the results (2000) based on different congestion cost estimations.

The deadweight loss reflects the economic costs in relation to an optimal traffic situation. The costs are roughly twice as high (63 billion Euro) as the figure presented in the 2000 study (33 billion Euro). The reason for this drastic increase is a methodological one, as

› (1) the networks of the VACLAV traffic model are more dense than the ones used in the 2000 study and
› (2) Traffic volumes, which are not considered by the VACLAV model, had been included here.

The two other approaches show the following results for 2000:

› Revenues from optimal congestion pricing amount to 753 billion Euros (8.4% of GDP).
› Additional time costs amount to 268 billion Euro (3.0% of GDP).

Although road freight transport accounts only for around 20% of traffic demand, its congestion costs are close to those of passenger vehicles. This fact can be explained by the comparably high use of road capacity by freight vehicles.

The charging revenues are the amount of money to be moved in order to remove the deadweight loss. In total across all countries they are roughly 12 times higher as the deadweight loss itself, which implies, that the transaction costs associated with charge collection are in the same order of magnitude as the expected social surplus. The delay cost measure is presented due to its simple definition and its comparability between road and public transport, but it does not reflect an economic measure.

Average external congestion costs in passenger transport are 56% higher than in the previous study. Besides the increase of transport volumes on the European road network between 1995 and 2000, this development is driven by the improved representation of urban traffic conditions and by the more detailed encoding of the inter-urban road networks within the VACLAV transport model.

In general the average cost results draw a realistic picture of the European road network conditions, where areas along the "Blue Banana" (southern England, the Benelux countries, Germany to northern Italy) show comparably high average cost results.

INTERNALISATION POLICY

In order to internalise external costs properly, imbedded in a wider concept of sustainable transport, the following action lines are most important:

› A Km-dependent HDV tax in overall Europe which considers not only accident costs, but also environmental costs like air pollution, climate change and noise. Possible tax levels are according to average shown in this report. It is appropriate to apply such schemes not only for motorways.
› The introduction of road pricing schemes for passenger cars, primarily in urban areas, to consider capacity problems. An additional differentiation according to environmental criteria (e.g. air pollution) is appropriate.
› A fuel price scenario in Europe for all means of transport in order to meet the aims of a long term climate strategy; the rates of the respective CO2-tax should be in line with the proposed shadow prices (at minimum 20 Euro per tonne of CO2 related to the Kyoto targets). Most important is the inclusion of international air transport, in order to reduce tax distortions between transport modes.
› Additional measures in road transport in order to increase effectiveness, such as hi-tech-road management and intermodal information systems, such as improved liability systems and environmentally friendly and safe driving styles, supported by traffic calming measures (incl. speed limits).

- The application of rail track pricing systems considering external costs according to EU Directive 2001/14.
- More emphasis of the railways to speed up technical progress in improving environmental performance, such as wagon break improvements (see UIC Noise Action Plan) and energy efficiency (see UIC Diesel Action Plan, use of sustainable energy sources).

These most important internalisation instruments should be underlined with a comprehensive multimodal strategy with the following core elements:

- Multimodal financial funds, financed (at least partly) by externality charges from the road sector. These funds secure the necessary financial means for the modernisation of the railways. In order to allocate these financial means properly, the socio-economic return of the investments should be a major criteria and transparent budgetary rules of the fund administration are necessary.
- A priority to internalise external accident and environmental costs in these sectors (road and air transport) first, because these cost categories are responsible for large parts of the total external costs, in order to finance the proposed multimodal fund.

1. INTRODUCTION

1.1. THE TASK

The UIC study on external costs of transport (INFRAS/IWW 2000) has shown quantitative figures for 1995 (incl. rough forecast for 2010) for congestion, accident and environmental costs of transport for all Western European countries. The figures consider total, average and marginal costs for all modes of transport and specific traffic situations. This study was and still is an important basis for the determination of the level and structure of external costs of transport at the European level. It was used as a reference also in the EU White Paper on Common Transport Policy 2010.

In the mean time the approach of external costs and respective internalisation policies has been further developed, as well at the scientific and the policy level.

- The new draft Road Directive for HDV of the EU-Commission (adjustment of EU Directive 1999/62) wants to consider parts of external costs, such as accidents.
- The first EU-Rail Package (especially EU-Directive 2001/14) considers the approach of marginal cost pricing for track charging.
- The EU-Commission is studying at the moment new pricing schemes for air traffic management charges.
- The approach of the INFRAS-IWW study was used to estimate external cost figures for Eastern European countries, commissioned by OECD and CEI (OECD 2003)
- Within the EU 5th Framework Research Programme, several projects present further methods and results for external costs figures. Most important is RECORD-IT (corridor estimates) and UNITE. UNITE has finished by end of 2003. This project has elaborated figures for marginal costs and total cost accounts (EU-countries and Switzerland 1996, 1998 and 2005). Although the focus is very similar to the aim of the UIC-study carried out by INFRAS-IWW, the methods and approaches are partly different. Based on a rather cautious scientific approach, the level of quantitative results of UNITE is lower than the level presented by INFRAS-IWW.

This background makes it necessary for an updated position of the railways for the future discussion of external costs and their internalisation in the transport sector. A new update study shall provide up-to-date results for total, average and marginal external costs for the year 2000, considering the new evidence of EU-research.

1.2. STRUCTURE OF THE REPORT

This report presents in a first part (chapter 2) the basic methodological approach for the update by reviewing the methodology used in the past INFRAS/IWW report in a critical manner, especially by considering the new results of UNITE. The methodology is primarily focussed on the estimation of total and average cost per means of transport. This part is structured along each cost component.

Chapter 3 presents the results for total and average cost 2000 for each cost component and country. There is an interpretation in relation to the previous INFRAS/IWW study.

Chapter 4 presents the results for marginal costs and compares the results with other studies (esp. UNITE).

Chapter 5 presents the comparison with 1995 figures and draws conclusions on policy implication. This chapter refers to previous work done by UIC (INFRAS 1998) on internalisation instruments.

The Annex is presenting input figures and further details on calculation methods.

2. UPDATE METHODOLOGY
2.1. GENERAL METHODOLOGICAL ISSUES
2.1.1. OVERVIEW OF COSTS CONSIDERED

Overview of costs considered

The following table gives an overview of the cost components considered in this study:

OVERVIEW OF EXTERNAL COSTS BEING CONSIDERED				
Type of effect	**Cost components**	**Method**	**Leverage points and variability**	**Type of Externality**
Accidents	Additional costs of - medical care - economic production losses - suffering and grief	The value of human life is estimated using studies for willingness to pay to reduce accident risks.	Depending on different factors (partly on vkm).	Partly external (part which is not covered by individual insurance), especially opportunity cost and suffering and grief.
Noise	Damages (opportunity costs of land value) and human health.	WTP approach for disturbed persons, medical costs and risk value due to transport noise	Depending on traffic volume and environmental performance.	Fully external
Air pollution	Damages (opportunity costs) of - human health - material/buildings - crop losses	PM10 dose response functions are the basis for the repair and damage costs.	Depending on vkm, energy consumption and environmental performance.	Fully external.
Climate change	Damages (opportunity costs) of global warming.	Avoidance costs (2 scenarios) to reach Kyoto targets per country or to reach long term reduction targets	Depending on consumption of fossil fuels.	Fully external.
Nature and landscape, ground sealing	Additional cost to repair damages, compensation costs.	Costs are based on unit types of repair measures, based on space indicators.	Fixed costs	Fully external.
Additional costs in urban areas (separation and space scarcity)	› Separation: time losses of pedestrians › Space scarcity: space compensation for bicycles	Cost calculation based on random sample evaluation for different cities in Europe.	Depending on traffic volume	Fully external.
Up- and downstream processes	Additional environmental costs (climate change, air pollution and nuclear risks)	Calculation of the impact of additional emissions contributing to air pollution and climate change based on Life Cycle Analysis data	Fixed costs (grey energy of infrastructure and rolling stock)	Fully external.

OVERVIEW OF EXTERNAL COSTS BEING CONSIDERED				
Type of effect	**Cost components**	**Method**	**Leverage points and variability**	**Type of Externality**
Congestion	External additional time and operating costs	Time costs and additional operating costs of road users due to congestion	Depending on traffic amount (number of vehicles)	Average costs are internal to the users. Differences between marginal and average costs are external costs.

Table 5 External costs categories within this study

2.1.2. DATA BASIS AND COUNTRY ALLOCATION

Harmonisation of transport data

In order to base the calculation of external costs for each country on consistent data, comparable figures for traffic and transport volumes, emissions, etc. are needed. There are two major sources for those data:

› Country figures based on official national or European statistics (EUROSTAT). Although these are official figures, a comparison between different countries is difficult since the elaboration of these figures usually follows different national methodologies and procedures. Although the publication 'Energy and Transport in Figures' (EC 2001, EC 2002) covers all EU15 countries and sometimes even Norway and Switzerland, the main data base for transport volumes are national statistics which show comparable problems to these described above.

› Standardised figures based on national performance figures like vehicle stock etc. TRENDS1 provides detailed transport data on a EU15 level which are considered to be comparable between countries and consistent even with national statistics (values are calibrated to reliable national statistics). The TRENDS1 database includes besides traffic volumes/mileage data, transport data, loading factors and emission data for the most important greenhouse gases and pollutants.

We have chosen the second approach for this update study, based on TRENDS database. However for some transport means additional or different data sources were used to improve the data situation. For a detailed description of the most important data sources for each transport mean and cost category please refer to the Annex.

Allocation of costs to countries

With respect to cost allocation to different countries a similar approach as in the INFRAS/IWW (2000) study was chosen. There are two basic approaches:

- Causer (nationality) perspective: all transport related externalities caused by users of a specific country are considered.
- Sufferer (territory) perspective: all transport related externalities being caused in a specific country are considered.

Basically we will allocate external costs from a territory perspective. However it was not possible to be consistent for every input data and cost estimation approach. Especially input figures for road transport are based on the nationality principle, because TRENDS1 data are derived from data on the national vehicle stock with additional assumption on average yearly mileage and load factors (to calculate pkm, tkm). Therefore an important basic assumption has to be made: Export and import of mileage (and, as a result of emissions) are balanced, e.g. if Swiss vehicles cause externalities in France it is assumed that vice versa French vehicles cause the same amount of external costs in Switzerland.

2.2. IMPLICATIONS OF RECENT STUDIES ON UPDATE METHODOLOGY

Recent studies on external costs of transports and transport accounts show several differences in methodology, valuation and basic data. Most differences in the resulting cost figures could be traced back to these three influencing factors. The most important studies are the following:

- UNITE: Unification of accounts and marginal costs for Transport Efficiency[1][2]
- Swiss Update Study on external accident costs road/rail (ECOPLAN 2002)
- Swiss Update Study on external air pollution costs (INFRAS/METEOTEST 2003)

ECMT (2003) states, those differences between studies can largely be explained by differences in 'statistics' (risk figures, traffic volumes, emission figures) and differences in normative choices with respect to transport policy rather than to transport economics. Sheer economic questions (valuation of pollutants etc.) play only a minor role.

1 There are other studies available like ExternE, TRENEN or RECORDIT. These studies are in general part of the UNITE-approach, since the teams were integrated. There are no further differences in methodology to state. Therefore we renounce to do present a full review of all individual reports.

2 Information on the 16 UNITE Deliverables and additional annex papers can be found on the UNITE webpage: http://www.its.leeds.ac.uk/projects/unite/

2.2.1. UNITE

Methodological commons

UNITE is the first European wide study within a EU research programme which has tried to estimate total, average and marginal costs for all means of transport. In general UNITE has followed the recommendations of the EU High Level Group. Besides some differences to the methodology of INFRAS/IWW (2000), there are a lot of commons which are important to raise credibility of external cost estimation.

› UNITE has used the same value of statistical life (to estimate accident and health costs) of 1.5 million EURO (average) as INFRAS/IWW (2000). Due to its sensibility, this is very important for the level of results.
› UNITE has used the same procedure of value transfer and update (according to GDP growth) as INFRAS/IWW. Benefit transfers between countries are generally made in line with real GDPs per capita, including a Purchasing Power Parity adjustment (PPP).

Methodological Deviations

The main methodological deviations to the UNITE study are the following:

› Data basis: UNITE has mainly used national statistics to estimate different costs. These deviate from European data like TRENDS for traffic and emission figures. Thus the comparability between countries is restricted within UNITE.
› Accident costs: share of external costs of total social accident costs: The UNITE approach is based on the assumption that traffic participants internalise the risk they impose when entering the traffic flow, but they don't internalise the risk they impose on others. Hence the external part is much smaller in UNITE than in the UIC study.
› Climate Change: Unit Costs per tonne CO_2: The main differences to the INFRAS/IWW (2000) study are due to different avoidance cost factors per tonne CO_2. This cost factor is highly dependent on the objectives for climate change policies and the measures which have to be taken to reach the greenhouse gas emission targets. In the INFRAS/IWW (2000) study a rather high shadow value (€135 per tonne CO2) was chosen which aims to reach very ambitious reduction targets (-50% between 1990-2030).[3] In addition, these targets have to be reached by taking measures within the transport sector. On the other hand the UNITE projects calculates with a rather low value (€20 per tonne CO2) which is based on less ambitious targets and full application of the flexible mechanisms in the

3 INFRAS/IWW has considered as well other avoidance scenarios within the sensitivity analysis. The lowest value corresponds to the UNITE approach.

Kyoto Protocol (e.g. emission trading, Joint Implementation (JI) and Clean Development Mechanism (CDM).

- Air pollution: Bottom up vs. Top down approaches: In UNITE the ExternE Model was used to calculate air pollution costs. The main differences to previous studies on external air pollution costs (see INFRAS/IWW 2000, Maibach et al. 1999, WHO 1999) can be explained due to different dose-response-functions on the one hand and different emission figures on the other hand. In addition, a completely different procedure to estimate total costs was used. The ExternE Model is a bottom-up 'impact pathway' approach which was used to calculate health costs in UNITE. Previous studies e.g. for Switzerland, Austria and France combined a top-down approach based on measured PM10 pollution data and a differentiated bottom-up model which quantifies the individual transport related population weighted PM10 exposure.

Consequences for this update study

UNITE has approved the valuation methodology of the EU High Level Group. The methodology is focused basically on marginal cost calculation. In addition UNITE has used in general a cautious approach based on solid scientific results. This leads to a slight bias for underestimation of external costs, since the risk element (and the problem that some costs cannot be estimated by solid methods) is an immanent problem of external cost analysis. Nevertheless we have to consider and compare the most important differences within each cost component. This will lead to a differentiation of the presentation of results, considering upper and lower bounds.

2.2.2. SWISS UPDATE STUDY ON EXTERNAL ACCIDENT COSTS

In October 2002 a new Swiss study on external accident costs for road and rail was published, which is basically an update of a similar study conducted in 1995 with the base year 1993. The study differs from the UNITE study (Swiss Pilot Accounts, UNITE 2002a) in two ways:

- Causer perspective in the Swiss study vs. victims perspective in UNITE: The victims (monitoring) perspective in UNITE is mainly applied due to data availability of monitoring data for most countries rather than information which allow cost allocation based on the causer principle.
- Distinction between internal and external costs with regard to the risk value: While UNITE takes the perspective of the transport system which implies that external costs

occur only if accident costs are not covered completely by participants of the transport system (e.g. subsidisation of hospital costs out of the public budget). All other costs as well as costs which arise with the accident victim are considered to be internal. In contrast in the perspective of the individual transport user external costs occur if the accident causer covers not all costs.

This approach is in line with the methodology used in INFRAS/IWW 2000 and demonstrates the different views of interpreting accident externalities.

2.2.3. SWISS UPDATE STUDY ON EXTERNAL AIR POLLUTION COSTS

Currently a new study on external air pollution health costs for Switzerland is in preparation (by ECOPLAN/INFRAS). Basically, the WHO 1998 (WHO 1999a-d) is updated with most recent emission data, a new dispersion model, new population data and updated dose-response functions. So far, a first intermediate report on population's exposure to PM10 was published (INFRAS/METEOTEST 2003). This report covers the calculation of a population weighted exposure of PM10. So far, the WHO (1998a) based dose-response functions were used to estimate air pollution costs. It is most likely that the final results are significantly higher than the ExternE-based figures of UNITE, since PM10 exposure is much higher. The Swiss update study supports the approach chosen in INFRAS/IWW (2000).

At the same time a study to update building damages is in progress (carried out by INFRAS). This study analyses new empirical evidence of the influence of air pollutants on building maintaining behaviour, esp. PM10. The study will be finished by springtime 2004. Recent interim results demonstrate that damage costs will be lower than shown in previous studies. At the same time the costs are significantly higher than computed by the ExternE model.

2.3. ACCIDENT COSTS

The methodological approach for the calculation of accident costs is mainly based on the INFRAS/IWW (2000) study. However, recent studies within UNITE show - as explained above - several deviations with respect to the internal and external part of the risk value. In this context the perspective taken is decisive on the share of internal and external part of social accident costs. From the perspective of the transport category (i.e. road/rail) or the transport system external costs only occur when social costs are not covered within a specific transport category or the transport system respectively. From the perspective of the individual traffic participant external costs occur when the causer of an accident does not cover the costs of an accident completely. In this case it doesn't make any difference whether the costs thereby incurred have to be covered by the not guilty victim of an accident, the general public or another transport category.

2.3.1. PROCEDURE OF COST ESTIMATION

We use for this update study the same approach as used in the previous study. The following cost components have to be considered to calculate social accident costs.

EXTERNAL ACCIDENT COST COMPONENTS		
Effect	**Fatalities**	**Injuries**
Risk Value	Loss of utility of the victim, suffering of friends and relatives	Pain and suffering of victims, friends and relatives
Human Capital Losses	Net production losses due to reduced working time, Replacement costs	
Medical Care	External costs for medical care before the victim deceased	External costs for medical care until the person completely recovers from his/her injury
Administrative costs	Costs for police, for the administration of justice and insurance, which are not carried by the transport users.	
Damage to property	Not included because material damages are paid by the traffic-participants through insurance premiums.	

Table 6

METHODOLOGY

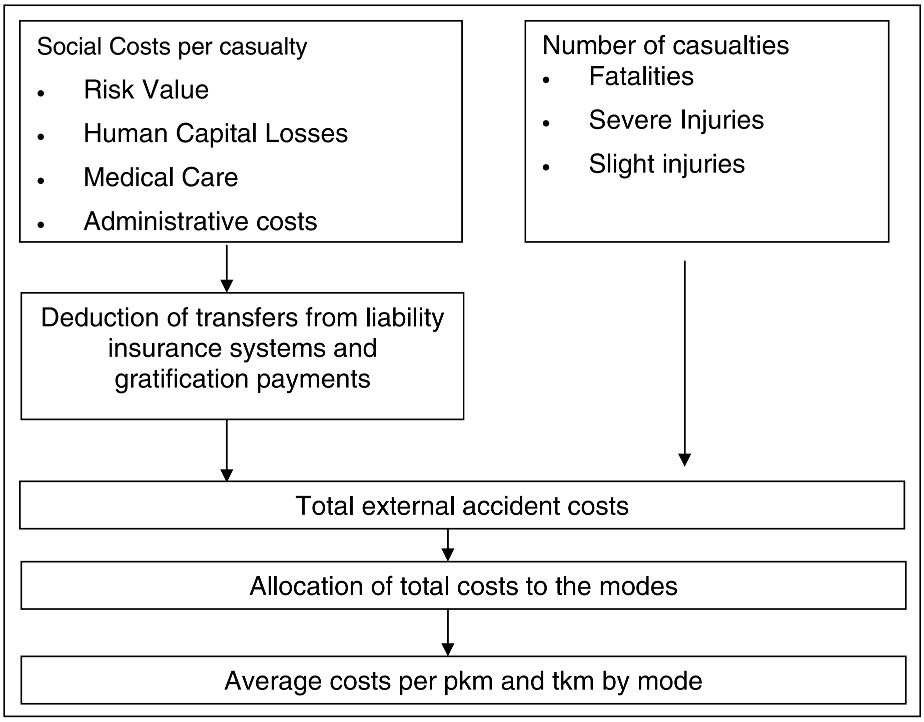

Figure 6

In a first step, the cost components per casualty are added in order to estimate social accident costs. External costs are then computed by subtracting transfers from liability insurance systems and gratification payments. The resulting external costs per casualty are multiplied with the number of fatalities and injuries.

The allocation of external costs to different vehicle categories depends on the available data. The IRTAD (2003) database reports accident fatalities and severe injuries (injuries which make hospitalisation of the victim necessary) from a victim's perspective. This means that no information on the causer of any accident is available in the database. A detailed analysis of German accident data was therefore used to allocate external cost to different road vehicle categories.

2.3.2. RISK VALUE

Risk Value for fatalities

Accidents are not only the cause of pain and suffering, but often shorten the lifetime of their victims. This clearly is a loss of welfare, which can be regarded as external costs that have to be quantified in monetary terms. The Risk Value tries to estimate monetary values for pain, grief and suffering on an average transport accident. Often it is argued (see UNITE) that at least a share of the Risk Value is internal because the traveller makes a decision to make a trip or not and in addition has the choice about his mode of transport. It can be replied however that accident risks are very small and therefore an adequate risk perception leading to a rational modal choice is very difficult if not impossible. As a consequence this study will regard the entire Risk Value as an external cost part.

As in UNITE (see Nellthorp et al. 2001) and the previous study on external costs of transport (INFRAS/IWW 2000) we suggest for the Value of Statistical Life (VSL) an amount of €1.5 million. A detailed discussion on the VSL and deduced values can be found in the both above mentioned studies. The Risk Value for accidents is used as well to estimate health cost for noise and air pollution effects. Due to the fact that the chosen VSL corresponds to an average value of many different WTP studies, an adjustment for the year 2000 is not necessary or would show pseudo accuracy.

The VSL will be adjusted to the countries according to GDP per capita.

Risk Value for injuries

The Risk Value for injuries is estimated as a share of the Risk Value for fatalities. The rates of the INFRAS/IWW (2000) study will be used due to data availability of accident data (no separation between severe permanent injury and severe permanent injury possible). In addition, the application of the same shares improves comparability between the former study and this update study.

The following Table 7 gives an overview on the risk values used in this study:

RISK VALUE PER CASUALTY
IN € 1'000

	Fatalities	Injuries	
		Severe Injuries	**Slight Injuries**
Risk Value	1'500	200	15

Table 7 Source: INFRAS/IWW 2000

2.3.3. HUMAN CAPITAL COSTS

Accident fatalities of injuries entail some reduction in the future social product of an economy. The production loss in this study will be calculated according to the UNITE methodology as Net Production Loss: gross production loss – future consumption.

Data for the net production loss will be derived from up-to-date EUROSTAT data.

2.3.4. OTHER EXTERNAL COSTS

The remaining external costs for medical care, replacement costs and administrative costs (police, justice, public administration) have been analysed for almost all EU17 countries in the UNITE project as well as in the new Swiss study on external accident costs (ECOPLAN 2002). For each country a best guess will be used. The adequate data from INFRAS/IWW and ECOPLAN (2002) will be adjusted according to GDP growth.

2.3.5. INTERNALISED SOCIAL COSTS

We will base our approach on the previous approach and ECOPLAN (2002). Thus the VSL will be used as well for self made accidents.

In addition often accident victims receive gratification payment or transfers from liability insurance of the party responsible. These transfers can be regarded as social costs that have been already internalised and thus have to be subtracted from total external costs.

2.3.6. DATA ISSUES

Data source

The international road Traffic and Accident Database (IRTAD 2003) is the main data source for road traffic accidents. The term 'hospitalised' defined by IRTAD for 'non-fatal accident victims admitted to hospital as patients' (IRTAD 2003) is used as the data for severe injuries. Unreported casualties are estimated according to IRTAD assessments (shares of non reported accidents remain the same than in the last study). Missing values for 2000 in the IRTAD (2003) database especially for severe injuries will be estimated with average values of those countries in the IRTAD database, where values are available. Also national statistic will be considered.

Rail Accidents

Since annual rail accidents vary considerably, the number of casualties is estimated by calculating the average of the years 1994-2000. The main database is the detailed UIC statistics. Accident at railway crossings which are – based on a detailed analysis in Germany – mainly caused by road users will be regarded as road accidents. Suicides are not considered.

Concerning injuries, no differentiated data for slight and severe injuries for rail transport were available. It was assumed that 25% of all rail injuries are severe injuries.

Air transport accidents

Accident data are taken out from the ICAO statistics and represents an average accident rate for scheduled air transport of European and North American Countries (scheduled services). Accident rates have the dimension 'fatalities/pkm'. Fatalities per country will be calculated by multiplying the accident rate with the respective transport volume in air passenger transport of each country. No Injures will be included (due to the lack of data).

2.3.7. MARGINAL ACCIDENT COSTS

The theory on marginal external accident costs is new and has been developed during the last few years. The empirical knowledge on marginal accident costs is therefore quite poor.

Marginal accident costs are these costs induced by an additional vehicle using the road network, which might cause positive or negative effects. It is possible that:

› drivers are disturbed by the growing traffic and therefore the number of accidents increases more than proportional, or
› that average speed slows down with increasing traffic and thus the number of accidents increases slower than traffic volumes, or
› a shift from severe to slight accidents occurs with slower average traffic speeds on congested roads.

Overall decreasing accident rates could be observed in Europe during the past 5 years. This might imply that marginal accident costs are decreasing in the same period. However, in the last decade new security relevant technological improvements such as antilock braking systems or airbags have become were popular in new cars. Therefore it is difficult to separate the effect of improved safety technology and the effect of increasing traffic volumes on accident rates and safety on roads. For a detailed discussion please refer to the previous study (INFRAS/IWW 2000).

In this update study average accident costs will be calculated. The discussion in the previous study showed that for medium traffic volumes marginal external accident costs are slightly lower or equal than average external accident costs. Other studies for motorways and inter-urban roads result in marginal costs which are slightly lower than average costs. This implies that an additional vehicle reduces speed and thus accident probabilities and severities.

In a second step we will present results of several UNITE case studies on marginal accident costs in Europe.

2.4. NOISE COSTS

Compared to the INFRAS/IWW external cost study 2000, the methodology for the estimation of costs of transport noise will generally remain unchanged in the present update-study. However, the database on inhabitants disturbed by transport noise used in the previous study, which was derived from OECD data of the year 1991, is improved substantially by new statistical information in this update study. Further, the cost rates, which are used for the assessment of the noise-exposed population, are adjusted to the year 2000. Moreover, the assessment method was supplemented with medical costs of diseases, caused by trans-port noise exposure. Figure 7 gives an overview on the updated methodology, which will be applied. The total external noise costs are mainly based on three cost elements:

› The Willingness to pay per person disturbed by a certain noise exposure level,
› The valuation of fatalities with risk value and
› Medical cost, which can be due to traffic noise

It is assumed that the obviously subjective WTP values come up to the decrease in property values, which can be considered as a more objective measure of factor costs. Thus it is well possible to sum up the WTP with the medical cost components to get the total external costs of transport noise.

ESTIMATION OF EXTERNAL NOISE COSTS

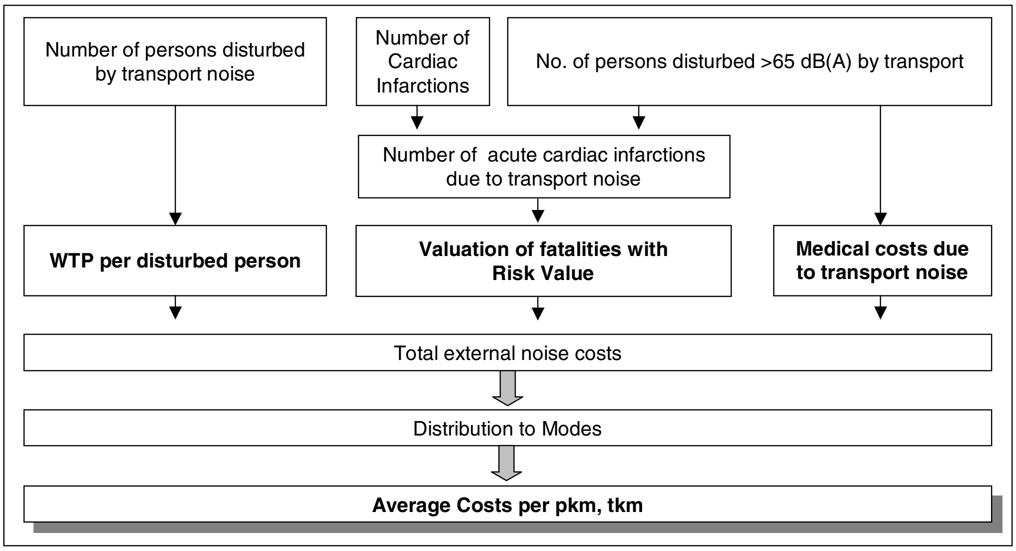

Figure 7 Methodology used for the estimation of external noise costs.

For some European countries recent and comparable noise data is not available. In these cases the data used in the 2000 study was also used here. Hereby, the assumption which was already taken in the previous report, that the increased noise emission of the growing traffic volumes and the improvement of traffic abatement measures equal out each other and thus the number of inhabitants exposed to transport noise remains more or less constant in the first place. The used database is documented in the Annex (page 140 ff.)

2.4.1. WILLINGNESS TO PAY FOR NOISE REDUCTION

Figure 8 gives an overview of the values found by empirical studies on the costs of transport noise in Europe. As during the past five years no new studies on the appraisal of transport noise emissions have been conducted in Europe, the assumptions on the development of the inhabitants' willingness-to-pay (WTP) for reductions in noise exposure remain unchanged compared to the last study.

Because absolute WTP values can hardly be compared across different countries, the data is set in relation to the per capita income. The incremental increase of WTP per dB(A) amounts to 0.11% of per capita income. Thus, the crucial difference of the investigations are not the marginal costs per dB(A) increase, but the target levels assumed, i.e. the point where the straight line crosses the x-axis. This study (and also the INFRAS/IWW 2000 study) will apply again a cautious approach using 55 dB(A). The gradient of the used function is nearly the same compared with the functions, which were found out by the analysis of the other studies (cp. Figure 8).

The adopted cost rates take into account the development of GDP per capita PPP growth rates between the last study (1995), where these rates were used and the present study (2000). The update factors between 1995 and 1999 were taken from the UNITE project, while, due to missing data, it was assumed that the annual grow rate of GDP per capita remained unchanged in 2000.

WILLINGNESS-TO-PAY FOR NOISE REDUCTION AS SHARE OF PER CAPITA INCOME.

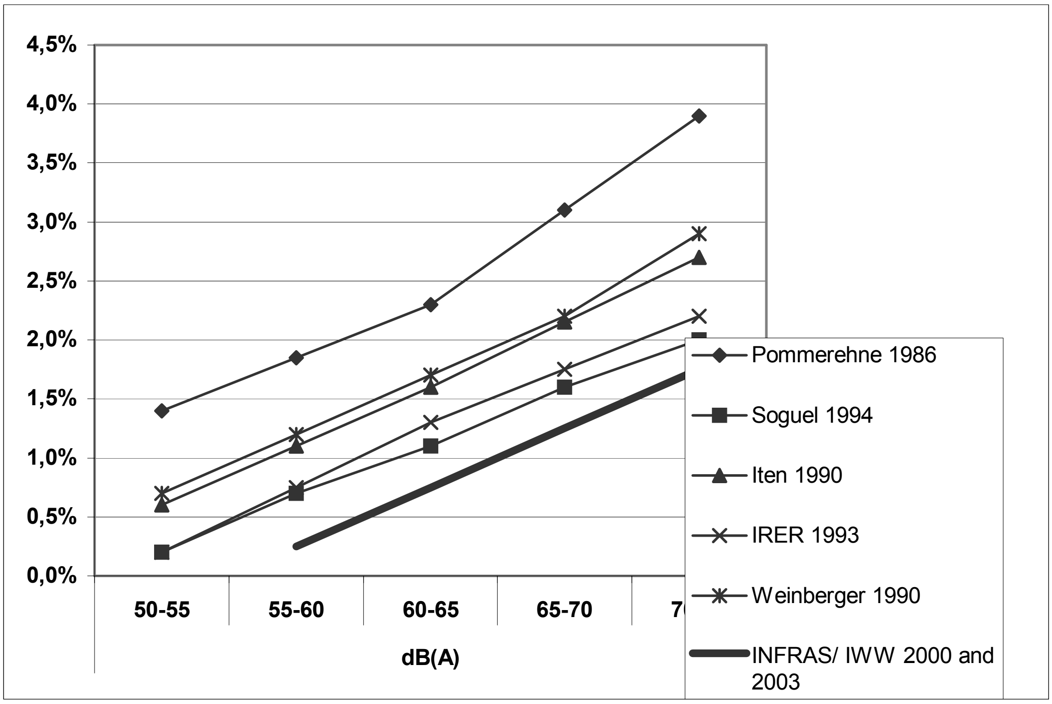

Figure 8 Development of the willingness to pay as a share of per capita income versus the different noise classes in different European studies.

According to the previous study (INFRAS/ IWW 2000) the WTP for the NL (noise level) in the reference country Germany will be calculated as follows (including the inflation rates between 1995 and 2000 coming from UNITE.

$$WTP(NL) = 21.23 * NL - 1168$$[4]

The following values with reference to Germany are used and extrapolated by PPS-adjusted national values of GDP per capita according to Table 44 in the annex for the other European countries. As there is no evidence that Germany takes a specific position within the European counties concerning the sensitivity of its population, the German evidence has been considered as European average.

REFERENCE VALUES GERMANY					
dB(A)	**55-60**	**60-65**	**65-70**	**70-75**	**>75**
Road, Air	53	159	265	371	477
Rail	0	53	159	265	371

Table 8 Reference values for Germany per person affected in Euro per reduced dB(A).

Compared to the previous study the reference noise costs per exposed person and year are differentiated by transport mode. In line with the legislation on noise impact in a number of European countries[5] and referring to various scientific reports[6], an adjustment of 5 dB(A) is applied for railway noise by 'shifting' the noise costs by one class. Background for the legislation is a different perception of railway noise compared to road noise.

2.4.2. VALUATION OF HEALTH RISKS

For the valuation of the increased morbidity and mortality caused by transport noise, it is important to determine the increased health risk in a first step. The health risk can be analysed in the same way we have already done for the last study. We will make the assumption that the cardiac infarct risk was not increased between this study and the previous. The literature to which our last study referred is still up-to-date. More recent studies only confirmed the data, which we have already quoted (Maschke et al. (1997), Babisch et al. (1993)). Further evidence can be drawn from a UK study for transport noise impacts in the 70-75 dB(A) class and above 75 dB(A), which reveals an increasing risk of cardiac infarctions by a steady exposure to transport noise above 75 dB(A). The results of the studies are listed in the following table:

4 The calculation methodology for the WTP in dependence from the regarded noise level can be different depending on the used approach. For example the German BVWP uses for the calculation of the WTP the following formula: WTP(NL)=25*-NL-125, based on (Weinberger 1991).

5 E.g. Denmark, France, Germany, the Netherlands, Switzerland.

6 Quoted in the previous study (INFRAS/ IWW 2000).

INCREASED RISK OF CARDIAC INFARCTIONS DUE TO TRANSPORT NOISE				
Source	**Location**	**65-70 dB(A)**	**70-75 dB(A)**	**75-80 dB(A)**
Babisch et al 1993	Caerphilly, Speedwell	+20%	-	-
Babisch et al. 1994	Berlin	-	+20%	+70%
Values used in this study		+20%	+30%	

Table 9

The valuation of the mortality, i.e. acute cardiac infarctions, which are caused by transport noise, is carried out with the value of a human life: 1.5 million € (cp. Chapter 2.3 on accidents).

2.4.3. MEDICAL COSTS

The valuation of mortality impacts, as described in the section above takes only into account the society's willingness to pay for preventing deceases or death cases, but not the direct costs of medical care for the affected inhabitants. While in the present case of noise impacts, these medical costs were unaccounted in the last two studies, the present study will take these costs also into account. A large number of diseases are caused by noise above 65 dB(A). Depending on the duration and intensity of noise, noise can lead to a multiplicity of health problems. These problems are for example:

- Impairment of the aural acuity.
- Negative influence on the vegetative nervous system:
  - High blood pressure,
  - Heart cycle complaints and
  - Disturbance of the digesting organs.
- Aggravation of risk for ischemic heart illnesses - comprehensive term for disease pictures, with which the coronary sclerosis (lack blood circulation of arteries) is predominant the actual disease cause, e.g.:
  - Angina pectoris,
  - Cardiac infarct,
  - heartbeat disturbances and
  - sudden heart death (cp. Valuation of fatalities).

The interrelationship between traffic noise above 65 dB(A) and ischemic heart illnesses can be proved statistically (cp. UBA 2000). According to data of the German Federal Environ-mental Agency it is possible to attribute altogether three per cent of all cardiac infarcts to noise disturbance. In Germany 1800 fatalities (in the year 2000) can be attributed to traffic noise (cp. UBA2000).

About 8 percent (cp. MOSCA 2002) of all economic costs of heart illness are caused by transport noise. This 8%-value represents the share of the cost of the cardiovascular diseases, which can be attributed to the road traffic noise starting from 65 dB(A). In the reference country Germany each person, who is exposed to a road traffic noise of over 65 dB(A) will be additionally assessed with an amount of 130€ for medical costs.
This additional medical cost factor will be calculated for each country as follows:

$$C_{Person}^{Med} = \frac{0{,}08 \cdot CHI}{NoP_{>65db(A)}}$$

C_{Person}^{Med}:	Medical cost rate per Person
CHI:	Total economic cost of heart illness
NoP>65dB(A):	Number of Persons exposed to a noise level over 65 dB(A)

2.4.4. MARGINAL NOISE COSTS

For the calculation of marginal noise costs this study uses the same methodology assumptions, which were already used in the previous study.

One of the most decisive characteristics of traffic noise concerning marginal costs is the interdependency between the number of sound sources, the emitted sound energy, its spatial dispersion and its perception by the human ear. On the exposure side the number of affected inhabitants and their sensitivity towards noise disturbance, determined by the type of land use and the time of day, is of great importance. Due to this great amount of influencing parameters the application of sophisticated emission-dispersion models to particular scenarios of traffic situations and settlement structures is required in order to be able to present concrete values of marginal noise costs.

The scenarios selected refer to three decisive characteristics, which are:
› three different types of land use (rural, suburban and urban),
› two time periods (day, night) and
› two traffic conditions (relaxed, dense).

The type of land use in combination with the time period determines the target level of accepted noise exposure. The type of land use further determines the settlement style and density, which finally results in the number of inhabitants exposed to noise and their aver-age distance to the noise source.

The following two tables show an overview about the physical and traffic parameters, which are used for the estimation of marginal noise costs.

PHYSICAL PARAMETERS FOR THE ESTIMATION OF MARGINAL NOISE COSTS						
Land use	**Rural**		**Suburban**		**Urban**	
Time zone	**Day**	**Night**	**Day**	**Night**	**Day**	**Night**
Target level in dB(A)	50	40	60	50	70	60
Distance to road / rail	100 m		20 m		10 m	
Settlement density	10%		50%		80%	
Inhabitants per kilome-	500		500		2000	
Affected inhabitants per	50		250		3000	

Table 10 Physical parameters for the estimation of marginal noise costs

TRAFFIC PARAMETERS TO ESTIMATE MARGINAL NOISE COSTS						
Transport mode		**Road**			**Rail**	
Area	**Rural**	**Suburban**	**Urban**	**Rural**	**Suburban**	**Urban**
Target level in dB(A)	131	221	521	HS	RT	LR
Distance to road / rail	2’400	1’200	800	60	60	20
Settlement density	6’800	4’800	2’650	30	30	5
Inhabitants per kilometre in built-up areas	130	80	40	250	160	80
Affected inhabitants per kilometre road/rail track	15%	10%	5%	100%	50%	20%
			+3.2	-5.0	-5.0	-5.0

Table 11 Traffic parameters to estimate marginal noise costs

Marginal costs for aviation

Compared to the previous study marginal costs of air transport are calculated on the basis of the available road and railway noise emission models. The ratio between marginal and average costs is estimated to be roughly 40%. As a range for the marginal noise costs of air traffic a range between 30% and 60% of average costs are considered.

2.5. AIR POLLUTION COSTS

2.5.1. VALUATION BASIS

Air pollution is responsible for different social and external costs which are relevant to consider. Within this update study the following elements are taken into consideration:

- Impacts on human health,
- impacts on materials and buildings,
- impacts on crops and agricultural production.

The most important new research study in the field of air pollution costs is the UNITE project (methodology: UNITE 2000a). Based on an Impact Pathway Approach (IPA) developed in the EC funded ExternE Project series a bottom up calculation of external air pollution costs was made. The study shows considerable differences to previous cost estimations, which can be interpreted for those countries covered by other studies (e.g. Switzerland). In UNITE 2002a (Pilot accounts for Switzerland) these differences were explained by two main reasons:

- Different base years for cost estimations (INFRAS/IWW 2000: 1995, WHO 1999a-d: 1996, UNITE 1998) and considerable differences in the underlying amount of PM10 emitted. The calculation of PM10 emissions was revised several times in the last years. One of the tricky points is hereby air chemistry and the role of non-exhaust particles due to tire and brake abrasion, whirling up of dust, etc. However, improvements in engine technology, the introduction of particle filters in trucks, public transport buses and recently in passenger diesel cars led to a reduction of PM10 emissions and will lead to further reductions in the future. But this refers only to exhaust emissions. The other emissions (even more important emissions due to abrasion, rising of dust etc.) will more or less develop in line with traffic volumes.
  One of the main reasons for differences in cost estimations in recent years are therefore different emission figures.
- The second and even more important reason for differences are substantial differences in the dose-response functions used in the ExternE model and applied in the WHO-Study. The functions in the ExternE model presume a much lower responsiveness of human health on exposure to air pollutants than those used in the WHO-Study. The differences amount to more than a factor 3 (the dose-response functions for long-term mortality shows even higher deviations to the function used in WHO (1999) and the previous study). This factor reveals considerable differences in the opinions of scientists with regard to the treatment of long-term mortality.

- However, it has to be stated that in UNITE the agreed methodology could not be applied for the computation of health costs in every single country. This was mainly due to poor data availability and differentiation in some countries. This problem was even bigger for the calculation of air pollution costs with the ExternE impact pathway approach, because level of detail and actuality of national emission inventories varies considerably between countries. While e.g. for Switzerland a complete, highly dissolved three-dimensional link model for transport related emissions was available, other countries could only provide total figures of transport emissions for one year, which were in addition based on relatively poor data.
- As a consequence, the ExternE impact pathway approach was only applied in a simplified way within UNITE. Especially local impacts which are particularly important for effects on human health where calculated based on cost factors found in Germany (€ per tonne PM10) and transferred to the other countries using total emissions. Besides, the dissolution of the regional model with which air chemistry related pollutants (especially secondary particles which affects human health) are estimated is rather rough (50x50 km) compared to the WHO study (see WHO 1999a-d). This study is the basis for the calculation of air pollution cost in the previous INFRAS/IWW (2000) study and used dissolution of 1x1 km for the computation of population exposure to transport related PM10. The currently ongoing update study has an even higher disaggregated exposure model (200x200 m) which is able to take local effects accurately into consideration.
- The Swiss update study on air pollution costs (see INFRAS/METEOTEST 2003 for first results) will use recent epidemiological studies (e.g. Pope et al. 2002) for improved dose-response functions. Discussions with the project team of the Swiss update study showed that the new studies used to calculate dose-response functions confirm rather the WHO values (see WHO 1999b) than those used in the ExternE project.[7]

7 Oral Information from Martin Röösli, Project Leader Epidemiology of the Swiss update study on air pollution costs, Institute for Social and Preventive medicine, University Basel, Switzerland from September 18th, 2003.

2.5.2. PROCEDURE FOR COST ESTIMATION

As explained above there are two main approaches to calculate air pollution costs:

1. **Top down allocation** (used in WHO 1999, INFRAS/IWW 2000, INFRAS/ METEOTEST 2003): This top down approach is based on unit values excerpted from these studies and transferred (with several indicators) to other countries.
2. **Bottom up approach (UNITE, ExternE)**: Use of the ExternE models to estimate values for different transport situations. This approach is first and foremost able to calculate marginal costs and was used in UNITE also to estimate total costs.

For this update study a top down approach will be applied, according to the methodology applied in WHO (1999a-d) and INFRAS/METEOTEST (2003). The following reasons support this procedure:

› Improved comparability with the past study (INFRAS/IWW 2000).
› Methodology approved by Swiss update study (INFRAS/METEOTEST 2003) especially with respect to dose-response functions and the general estimation procedure.
› Data situation: to apply a bottom up methodology detailed emission inventory data is needed. The collection of spatial information on transport emissions, population exposure and background emissions of other sources for all EU17 countries would go far beyond the scope of this update study.

The following figure shows the most important estimation steps:

METHODOLOGY HEALTH COSTS

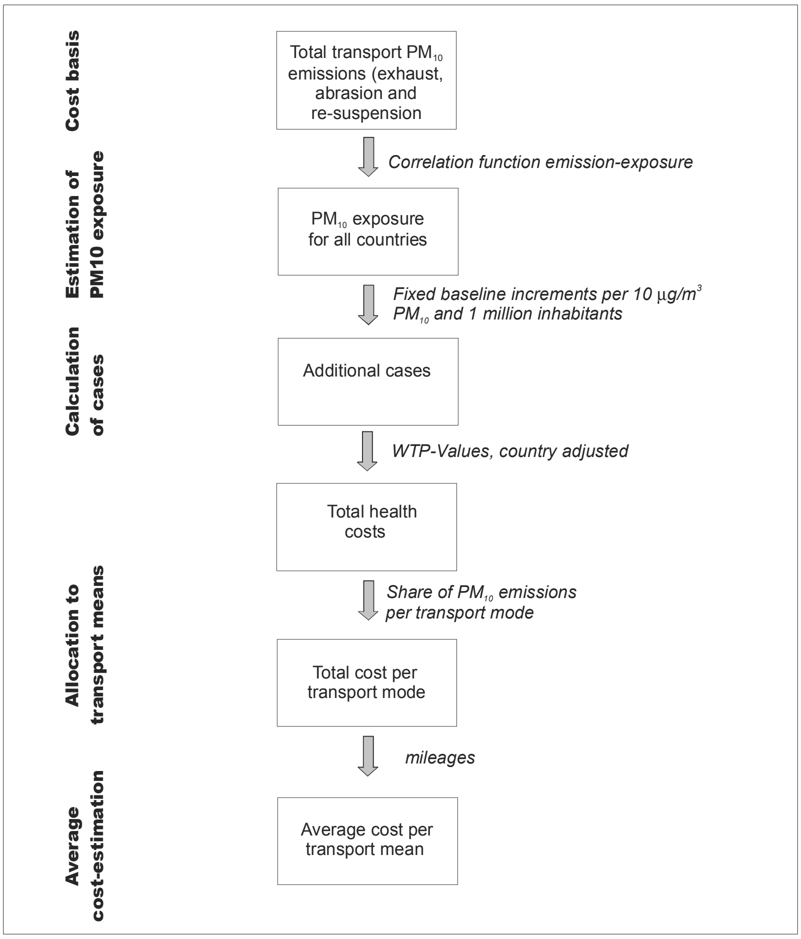

Figure 9 Methodology use for the estimation of health costs.

In the following sections the different estimations steps are described in detail.

Total emission data

PM10 was chosen as tracer substance (according to INFRAS/METEOTEST 2003 and most other air pollution cost studies). Road, Rail and Aviation Emissions are taken from the TRENDS 1 database considering non-exhaust emissions as well (see section 0 for detailed emission data). For non-exhaust emissions new emission factors were available from a recent Swiss study (BUWAL 2002 and BUWAL 2003). Especially road non-exhaust emissions have been overestimated in the past while non-exhaust emissions of rail transport was underestimated significantly (refer to the Annex for detailed emission factors).

PM10 exposure

Using correlation analysis with weighted mean of PM10 emissions including non-exhaust emissions and PM10 exposure data for Austria, France and Switzerland the population weighted PM10 exposure will be estimated.

Calculation of additional cases

For the calculation of additional cases caused by transport PM10 emissions, the fixed baseline increase function from the WHO-study was used (WHO 1999a-d). As soon as updated functions from the currently running Swiss update study are available, these values can be adjusted accordingly:

HEALTH EFFECTS OF PM10 EXPOSURE
Fixed baseline increment per 10 µg/m³ PM10 and 1 million inhabitants
additional cases (+/-95% Confidence Interval)

Health effect	Austria	France	Switzerland	Mean
Long-term mortality (adults >= 30 years)	374	340	337	**350**
Respiratory Hospital admission (all ages)	228	148	133	**170**
Cardiovascular Hospital Admission (all ages)	449	212	303	**321**
Chronic Bronchitis Incidence (adults >= 25 years)	413	394	431	**413**
Bronchitis (children< 15 years)	3'196	4'830	4'622	**4'216**
Restricted Activity Days (adults >= 20 years)	208'355	263'696	280'976	**251'009**
Asthmatics: Asthma attacks (children < 15 years)	2'325	2'603	2'404	**2'444**
Asthmatics: Asthma attacks (adults >= 15 years)	6'279	6'192	6'366	**6'279**

Table 12 Number of additional cases per 10 mg/m³ PM10 and 1 million inhabitants. For all countries with the exception of Austria, France and Switzerland the same mean values were used.

The exposition values will then be used to calculate the cases of morbidity and mortality which were finally multiplied with country adjusted WTP values to receive total external transport health costs.

Total Health Costs

The following table show the WTP values for air pollution health effects:

WILLINGNESS TO PAY VALUES FOR AIR POLLUTION HEALTH EFFECTS		
Incident	**Value [Euro]**	**Unit**
Long-term mortality (adults >= 30 years)	915'000 (61% of 1.5 million.)	per life lost
Respiratory Hospital admission (all ages)	7'870	per admission
Cardiovascular Hospital admission (all ages)	7'870	per admission
Chronic Bronchitis incidence (adults >= 25 years)	209'000	per case
Bronchitis (children< 15 years)	131	per case
Restricted Activity Days (adults >= 20 years)	94	per day
Asthmatics: Asthma attacks (children < 15 years)	31	per attack
Asthmatics: Asthma attacks (adults >= 15 years)	31	per attack

Table 13 Willingness to pay: Average European values for the valuation of air pollution health costs, Prices 1995. Source: INFRAS/IWW (2000), WHO (1999)

As in the WHO study we will correct the risk value considering age. Because the mortality risks are increasing with age, the risk value is reduced to 61% of the total estimated value of 1.5 million € (see WHO 1999a-d for detailed argumentation). Values were adjusted in time using GDP deflators (OECD 2002) and adjusted to the different countries.[8]

Total costs per transport mode

Total costs will be allocated to transport modes according to their share of total PM10 emissions and total PM10 exposure respectively.

2.5.3. MARGINAL AIR POLLUTION COSTS

In this update study no separate bottom-up calculation of marginal air pollution costs could be made (in the previous study marginal air pollution costs were calculated using the ExternE model).

Since dose response functions for the calculation of air pollution costs are linear functions and exposure calculations are in our top-down model also linear functions, marginal air pollution costs are approximatively equal to average air pollution costs.

8 In contrast to the previous study INFRAS/IWW (2000) the willingness to pay values are interpreted as European values and therefore adjusted using GDP PPP with EU17=100. In the previous study the cost values were regarded as Swiss values and therefore adjusted using GDP PPP with Switzerland = 100.

2.6. CLIMATE CHANGE COSTS

It is assumed that the damage caused by greenhouse gases (GHG) has a global scale. This means there is no difference how and where the emissions take place in the world. Higher concentrations of GHG cause a change of global temperatures with its regional consequences on rainfalls, frequency of hurricanes and dry periods, on sea level and eventually on sea currents. These changes in global climate can imply land losses in highly populated regions, extreme climatic events, crop losses, health effects (e.g. due a widening of the regions infested with malaria), etc.

The transport sector plays an important role in the GHG discussion. It is the fastest growing economic sector (47% growth since 1985 within EU) and consumes more than 30% of final energy. Because of the fuel dependency of the transport sector, energy consumption has also resulted in an increase in greenhouse gas emissions. A major source of anthropogenic CO_2 emissions is transport contributing about one fourth of the EU total (T&E 2003).

Other green house gases – like methane or N2O – are not accounted in theses calculations. In green house gas equivalents theses gases caused by road, rail and air traffic stand for a relevant part of the climate change potential within the EU17 countries (see GHG-Inventories).

Valuation basis

The costs of CO_2 emissions are basically calculated by multiplying the amount of CO_2 emitted by a cost factor. This substantial factor for the calculation of the costs of the climatic change is the shadow value in currency per tonne CO_2. The costs for the avoidance of CO_2 output depend strongly on the objectives for climate change policies and strategies (resp. mechanisms) via which these objectives would be reached. We can differentiate for example between the

- Kyoto targets (2008 – 2012) applied at EU-level,
- The reduction targets set by a country or by international treaty[9]. Some examples are shown in Table 14.

9 Reference to Article 2 of the UNFCC (UN Framework convention on Climate Change) stipulating "the ultimate objective of this Convention is to achieve a stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous interference with the climate system" implies a reduction of world-wide CO_2 emissions by 50% (IPPC), or of 80% for OECD countries (indicated in the presentation of P. Wiederkehr at the UIC Railway Energy Efficiency Conference in February 4th, 2004).

CO_2 REDUCTION TARGETS	
Reference/Study	**Scenario**
United Kingdom	
Royal Commission on Environmental Pollution. *Energy – the changing climate*, June 2000 Document submitted to the Parliament	Proposal of reduction of CO_2 emissions up to 60% in 2050 compared to 1997 (reference year)
Germany	
Wuppertal Institut für Klima, Umwelt, Energie/Centre allemand de recherche spatiale (DLR)/Institut für Thermodynamic. *Langfristszenarien für eine nachhaltige Energienutzung in Deutschland*, July 2002 Report for the Environment Federal Agency (Umweltbundesamt, UBA)	National reduction target for CO_2 emissions up to 80% in 2050 compared to 1990 level
Switzerland	
Prognos AG *Ergänzungen zu den Energieperspektiven 1990-2030 – Scenario IV : verschärfte und auf Nachhaltigkeit ausgerichtete CO2-Reduktion* Report for the Energy Federal Office (Bundesamt für Energiewirtschaft)	National reduction target for CO_2 emissions up to 60% in 2030 (with 55 % for transport sector) compared to 1990 level
France	
National Climate Change Programme Prime Minister speech - Lyon – October 2002	Proposal of reduction target for CO_2 emissions of 75% in 2050 for industrialised countries
International targets	
International targets	› Reference to Article 2 of the UNFCC (UN Framework convention on Climate Change) stipulating "the ultimate objective of this Convention is to achieve a stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous interference with the climate system" implies a reduction of world-wide CO2 emissions by 50% (IPPC), or of 80% for OECD countries. › European 6th program of community action for environment, target: 70% of reduction regarding to 1990 levels.

Table 14

Within these goals the following mechanism could be pursued:

› Reduction of the total CO_2 emissions at national levels (inland).
› Reduction of the CO_2 emissions of a certain sector (industry, transport, households etc.) in the inland.
› Reduction of the total CO_2 emissions worldwide, which are released by a country (e.g. with tradable CO_2 certificates).

- Reduction of the CO_2 emissions of a certain sector (industry, transport, households etc.) worldwide (e.g. with tradable CO_2 certificates).
- All conceivable combinations.

In the following tables a selection of available shadow values is shown. It gives an overview of the large range of valuations for prices of emitted CO_2 for energy efficiency projects, mainly in the industrial sector, and specific ones to the transportation sector.

SHADOW VALUES USED FOR ENERGY EFFICIENCY PROJECTS	
Netherlands ERUPT-2 program (part of the Carbon-credits.nl program)	Average price of the carbon credits is 4.78 € per tonne of CO_2-eq. emitted (25 mill. € for 5.23 Mt CO_2 eq.) Countries involved: Romania, Slovakia and Hungary See: JIQ 2002c
AIJ pilot program of Finland	Estimated price 6 to 8 € per tonne of CO_2-eq. emitted. Countries involved for CDM[10]: El Salvador, Nicaragua, Thailand and Vietnam Countries involved for JI[11]: Estonia, Latvia, Lithuania, Poland and Russia See: JIQ 2002b
China's CDM projects	Estimated price 10 US$ per tonne of CO_2-eq. emitted. At this average price China could reduce 15% of its GHG emissions compared to the national baseline. See: JIQ 2002a
UK emissions trading scheme (ETS)	Price approx. 85 € per tonne of CO_2-eq. emitted. This value was found in an auction, where the UK government distributed the amount of 225 £ among the participating firms in exchange for emission reduction commitments. See: JIQ 2002a
Chicago Climate Exchange (CCX)	At the first auction of CO_2 emissions allowances (September 30, 2003) an average successful bid price of 0.98 US$ per metric tonne of CO_2 for 2003 and 0.84 US$ per metric tonne of CO_2 for 2005 was found. See: SAM 2003

Table 15 List of shadow values for CO_2-eq. emissions for energy efficiency projects.

10 Clean development mechanism
11 Joint implementation

TRANSPORTATION SECTOR: ESTIMATIONS OF MARGINAL AVOIDANCE COSTS	
Study	**Value**
UNITE The pilot accounts for Germany	
Shadow value	20 € per tonne of $CO_{2.}$ emitted (avoidance costs). This value lies within a range of values of € 5 to € 38 per tonne of CO2 avoided presented by Capros and Mantzos (2000).
Scenario	Average value chosen by UNITE.
Source	UNITE 2002b
UNITE pilot accounts for Switzerland	
Shadow value	20 € per tonne of CO_2 emitted (avoidance costs)
Scenario	European average cost estimate of meeting the Kyoto targets
Sensitivity analysis	80 € per tonne of CO_2 for a Swiss sensitivity analysis (average from the study Maibach et al., 1999).
Data basis	› Road transport: CO_2 emission data › Rail and urban public transport: calculated from information an energy consumption and the electricity production mix › Aviation: calculated from fuel consumption data
System border	Aviation: territoriality principle of the UNITE pilots accounts
Source	UNITE 2002a
Fahl	
Shadow value	19 € per tonne of $CO_{2.}$ emitted (avoidance costs). This is equivalent to ca. 4.6 €-Cent per litre gasoline and ca. 5.1 €-Cent per litre diesel (Environmental external costs of transport, Friedrich and Bickel, Stuttgart, 2001).
Scenario	Meeting the Kyoto targets in Germany (Fahl et. al. 1999)
Source	Fahl et al. (1999) used in UNITE 2002b
Duerinck	
Shadow value	25 € per tonne of $CO_{2.}$ emitted (avoidance costs). This value lies within a range of values of € 5 to € 38 per tonne of CO2 avoided presented by Capros and Mantzos (2000). This is equivalent to ca. 4.6 €-Cent per litre gasoline and ca. 5.1 €-Cent per litre diesel (Environmental external costs of transport, Friedrich and Bickel, Stuttgart, 2001).
Scenario	Meeting the Kyoto targets in Belgium.
Source	Duerinck J. et al. 1999 used in UNITE 2002b
INFRAS / IWW	
Shadow value	135 € per tonne of CO_2 emitted, with a range of 70 up to 200 € calculated over a large range of marginal abatement costs from different studies
Scenario	Reduction target 50% in 2030 compared to 1990 (recommended by IPCC), which are more stringent reductions than the Kyoto aims are to reach sustainability.
Source	INFRAS/IWW 2000

TRANSPORTATION SECTOR: ESTIMATIONS OF MARGINAL AVOIDANCE COSTS	
Study	**Value**
Capros and Mantzos	
Shadow value	38 € per tonne of CO_2 emitted (1990 prices), without international emission trading.
Scenario	Meeting the Kyoto targets in EU.
Source	Capros P., Mantzos L. 2000
Criqui and Viguier	
Shadow value	37 US$ per tonne of CO_2 emitted. With international emission trading this amount could be reduced to ca. 14 US$ per tonne of CO_2.
Scenario	Meeting the Kyoto targets in EU.
Source	Criqui, Viguier 2000
Commissariat Général du Plan - France	
Shadow value	27 € per tonne of CO_2 emitted (avoidance costs).
Scenario	Meeting the Kyoto targets in France, by using clean development measures and emission trading. A shadow of 41 € per tonne of CO_2 emitted, when the Kyoto targets have to be met within the European Communities.
Source	Boiteux M., Baumstark L. 2001
Krom et al. (ETSAP study)	
Shadow values	The study shows for different countries shadow values: Belgium: 80 $ per tonne of CO_2 Netherlands: 25 $ per tonne of CO_2 Sweden: 170 $ per tonne of CO_2 Switzerland: 160 $ per tonne of CO_2
Scenario	Prices 1996, abatement costs for reduction commitments in the Kyoto protocol.
Source	ETSAP 1996

Table 16 Overview of shadow values for CO_2 emissions for the transport sector for avoidance costs found in literature.

Compared to the shown avoidance costs in Table 16 **damage costs** estimated in the study of Friedrich and Bickel (2001) are lower by a factor of 10 to 100. They calculate a shadow value of 2.4 € per tonne of CO_2 with a range from 0.1 up to 16.4 € per tonne of CO_2. In the estimation process for this values are enormous uncertainties involved. An argument might be that damage costs only contain costs of impacts that are reasonably well known and understood, whereas there might be further impacts not known today. Another study (Hohmeyer et al. 1997) shows that damages costs due to a loss of agricultural production in 50 years can be valued at 0.7 $ up to 3.3 million $. We decide to base to valuation on the avoidance cost approach.

The shadow price in the INFRAS/IWW 2000 study (€ 135 per tonne CO_2) results from an ambitious reduction target (-50% between 1990 and 2030) and a strategy which is more inflexible than worldwide emission trading, because the reductions should be reached within the European transport sector only. This view accompanies the long term investments as it is usual for transport infrastructure. Lower shadow prices would be achieved by set less ambitious targets and apply more flexible mechanisms within the Kyoto Protocol[12]. We use a shadow price of **€ 140 per tonne CO_2 as upper value for long-terms objectives (Scenario High)**, because the transport sector – particularly railways – are characterised by long-run investments. Following IPCC long term targets should be much more stringent than Kyoto targets to reach sustainability in the transport sector. On the other hand we used **a lower value of € 20 per tonne CO_2 (Scenario Low)** for short term targets – as defined in Kyoto Protocol – to calculate the lower bound of climate change costs (see Table 17).

SCENARIO AND BANDWIDTHS USED IN THIS STUDY	
Scenario	**Avoidance costs**
Lower boundary: International approach to meet Kyoto targets	20 € per tonne CO_2
Upper boundary: National transport approach to reach long term cut of CO2 emission by 50% (2030)	140 € per tonne CO_2

Table 17

Additional altitude effects of aviation are mentioned in the IPCC report "Aviation and the Global Atmosphere" (IPCC 1999). The concept of **radiative forcing** describes the additional thermal power (in watts per square meter) reaching the earth's surface due to the increased greenhouse effect caused by the emission of pollutants. Combined radiative forcing of aviation emissions was estimated at **2.5 times higher** than pure CO_2 related radiative forcing. This factor was also used for the cost calculations of aviation transport.

2.7. COSTS FOR NATURE AND LANDSCAPE

2.7.1. PROCEDURE FOR COST ESTIMATION (ROAD, RAIL AND AIR)

There exist different issues and valuation approaches to describe nature and landscape costs. In this study we use a bio centric approach – in contrast to anthropocentric approach estimates based on willingness to pay for specific types of landscape (see for example Infraconsult 1998, Blöchlinger/Jäggin 1996). From an economic point of view, the

12 Clean development mechanism, emission trading and joint implementation

willingness to pay approach would be most feasible. But a direct valuation of transport related damages is however not available (see Infraconsult 1998).
Thus we refer to a more pragmatic but consistent approach, like in the past UIC study. The bio centric approach starts from the definition of the scarcity of nature defined by experts. Recent infrastructure projects raise different compensation and avoidance costs, due to specific affords of environmental impact analysis. Thus the average costs per km of new infrastructure are significantly higher than the cost of old infrastructure. Based on a network classification, costs are estimated which are necessary to improve existing infrastructure to a level that is more or less compatibly with the needs of the environment. A set of unit costs (€ per km of infrastructure) based on repair and compensation cost approach is needed for calculations too.

The allocation of the cost per transport mode to the vehicle categories is based on specific assumptions which are discussed below (see also INFRAS/IWW 2000).

Road network

- The lengths of the roads are given in EU Energy and Transport in Figures (2001) (see Annex).
- An average road width by type of road is calculated and aggregated for the other European Countries. Figures of road widths are based on situations from Germany and Switzerland (BfS 1991, Gühnemann 1999). German roads are generally wider than in Switzerland (especially motorways). To calculate the average we assume that the big European countries correspond to the road widths of Germany and the small to the Swiss data.
- Estimation of the share of the sealed area caused by road infrastructure since 1950
  - 100% of motorways are considered although some of them had been built before 1950 (30% in Germany, 0% in Switzerland) because their impacts to nature and landscape are severe (barrier effects).
  - For all other roads, which were built after 1950 and pass rural area, a percentage of 30% is accounted.
  - Affiliated road features such as rest stops, maintenance facilities and entrance/exit areas are excluded.
- We consider that at least 5 m roadsides correspond to a total loss of natural area (IWW 1998). A recent study (econcept/nateco 2003) takes a width between 10 to 50 m on both sides of the road, distinguished between small roads up to highways.

Rail network

- The length of the rail network is given in UIC (2000) (see Annex).
- Widths of rail tracks are distinguished between single and double and more tracks. We assume an average width of 6 m for a single track resp. 13 m for double or more tracks (IWW 1998)
- Because the rail network has not been grown since 1950, the state of infrastructure is not relevant. For example, Germany's rail network is about 15% shorter than in the year of 1950. Regardless they are some negative effects to nature and landscape coming from the today's rail infrastructure (especially the high speed network which was build after 1950). We assume that 10% of total rail network have negative effects to nature and landscape.
- No complete loss of soil functions results from rail infrastructure, as this is the case with sealed area (for example water can trickle away). A German study (IWW 1998) estimates the rate of sealing of rail tracks about 50%.
- An additional width of 5 m is considered to calculate the additional impaired area at rail track sides. This is the half of the affected width which is used in a Swiss study econcept/nateco (2003).

Aviation infrastructure

- The number of all airports per country we take from INFRAS/IWW 2000 (see annex).
- Estimation of the sealed area of national and regional airports:
  - We assume an average sealed area of about 300 hectares for national airports in Europe. This corresponds to the sealed area of the airport Zurich – Kloten.
  - For regional airports we take an area of 80 hectares.
- Most of the airports were built after Second World War. For this reason the whole (100%) sealed area of airports is considered in the calculations.
- The additional impaired area by airports is calculated by assuming an additional radius of 50 m for national airports resp. 25 m for regional airports.

2.7.2. VALUATION BASIS (ROAD, RAIL AND AIR)

This approach divides the external costs for nature and landscape up into different cost components (modules). It has to be quantified the repair and compensation measures of each cost module. These costs are expressed in costs per m^2 of sealed area respectively of additional impaired area.

The approach considers only the concrete costs and more or less calculable ones, because several externalities of nature and landscape cannot be quantified.

Unsealing costs:

To repair and compensate the damages of nature and landscape caused by transport infrastructure, one has to unseal this area. The cost of this process was calculated by a German study (IWW 1998) with an average value of 50 DM/m² (price level 1995).

Restoration costs of target biotopes

After the unsealing process initial biotopes are not yet repaired properly, the area has to be restorated. Existing studies (Bosch & Partner 1993, IWW 1998) show us a wide range of these restoration costs. We assume that the average costs of reinstall a target biotope[13] are 20 DM/m² (price level 1995).

Soil/Water pollution

The estimation of these costs is very difficult and experts cannot quantify these costs in relation to transport infrastructure. An existing study (Froelich and Sporbeck 1995) calculated costs of 70 DM/m³ (price level 1995) soil[14] which have to be carried off and deposited. As in INFRAS/IWW (2000) we assume that the soil is polluted to a depth of 20 cm and that water purification processes cost more or less the same.

Other impacts

To quantify other externalities (barrier effects, visual effects, ...) to nature and landscape, we estimate the costs of 20 DM/m² (price level 1995) in this approach. Existing qualitative studies (Forman R.T.T. et al. 1998) assume that the importance of these studies is given.

Cost allocation

› The allocation of road transport is according to PCU (Passenger Car Unit):

› Passenger Car	1
› Motorcycle	0.5
› Bus	3
› LDV & HDV	2.5

› The allocation of rail transport is according to train kilometres.[15]

› The allocation of air transport is according to the aircraft movements.

13 In this study, we exclude the very valuable biotopes (like extensive used biotopes) because most of the traffic network goes trough 'normal' (intensive used) area.

14 These costs are probably too low because a purification process of soil is not included.

15 A distinction between electrified and not electrified rail tracks has not been made, although the damages are different. Whereas the pollution of diesel tracks (due to air pollutants) is mainly causing soil and groundwater problems, electrified tracks are causing soil problems (due to abrasion) and visual intrusion due to electricity wires.

Time period

To calculate the annual total external costs, we divide the total costs of the time period (1950 – 2000) by the number of years (50 years).

Country aggregation

The opportunity cost of a society depends on its purchase power. Thus, we will consequently translate the values - derived from a representative sample of studies - from one country to another. Therefore we use the purchase power parity rule. Unit values will be adjusted by weighing exchange rates with purchase power values.

Adjustment in prices

We adjusted the costs per m^2 which base on 1995 with the consumer price index (Statistisches Bundesamt 2003):

› consumer price index 1995: 93.9

› consumer price index 2000: 100

2.7.3. INLAND WATERBORNE TRANSPORT

The detailed approach which is trying to determine the costs of some repair and compensation measures is equal to INFRAS/IWW 2000. A short overview and description of the methodology is given with the following articles.

Network data

The length of channels (artificial waterways whose construction destroyed natural area) has to be known to determine the most important negative effects of waterborne transport. These data are given in the EUROSTAT statistical yearbook of regions (EUROSTAT 1997). Unfortunately, data are lacking for some countries (see annex).

Determination of impaired area by channels

A German study (IWW 1998) estimates that the total use of area is between 9 and 10 hectares per km channel (included are slopes, dimensioning of waterways and waterway ancillaries like sluices). They assume that the sealed area which depends on the lining of the bottom and the sort of slopes is at least one hectare per km channel. Further we assume that the renaturation area corresponds to the area of slopes which cover between 3 and 4 hectares per km channel (IWW 1998).

Cost determination

› Unsealing costs: We take unsealing costs of 50 DM/m^2 (price level 1995) as for the other means of transport.

- Restoration costs for slopes: The IWW study recommends average costs of 770 DM/m[2] (price level 1995) to reinstall extensive used biotopes at humid habitats (as marsh lands, reed beds).
- Renaturation costs of banks: IWW (1998) estimates the renaturation costs of enlarged banks at 700 DM/m (price level 1995).
- We adjust these costs with the same consumer price indexes as we used for road, rail and air transport.

Country aggregation/Consideration of time period

The calculated values are adjusted by weighing exchange rates with purchase power values. Further we consider a time period of 50 years which corresponds to the time from 1950 till 2000.

2.7.4. PROCEDURE FOR THE ESTIMATION OF MARGINAL COSTS

Based on the assumption that infrastructure is fixed in the short run, no short run marginal cost will occur in regard to nature and landscape. One exception is specific separation (barrier) effects for fauna, which might slightly depend on traffic volume. Since it was not possible to estimate these costs in detail, we consider this effect to be negligible. That means: Cost for nature and landscape are only relevant in the long run, where marginal costs are near to average costs of road infrastructure, if we assume that future infrastructure construction is likely to grow at the same rate as in the past.

Besides, there is a question if these costs do differ between different traffic situations and regional characteristics, especially between urban and non-urban areas. This depends very much on the concrete case. Since the range of future changes is very complicated, a distinction is very artificial. However we consider long term marginal costs only relevant for non-urban situations. For urban situations, future infrastructure will not cause additional damage to nature and landscape, but will increase scarcity problems.

2.8. ADDITIONAL COSTS IN URBAN AREAS

2.8.1. VALUATION APPROACH

The methodology used to calculate additional costs in urban areas is based on the previous study (INFRAS/IWW 2000). The main input parameters were updated and cost indicators adjusted to 2000 values. For further detailed information on the methodology we refer to the INFRAS/IWW (2000).

Basically two effects were considered:

› time losses due to separation effects for pedestrians

› scarcity problems (expressed as the loss of space availability for bicycles).

Another possible effect (urban visual intrusion due to transport volume and infrastructure) is very difficult to measure and no reliable estimates are available. Therefore this effect was excluded from the calculation.

Both considered effects are attached to the road sector in urban areas, and, to some extent, also to rail transport. It has to be mentioned that the estimation of these elements still is of a pilot character. We have to note however, that both approaches used are just a proxy for urban traffic damages. The legitimisation of these costs is based on a fairness principle: The road sector is leading to space scarcity in cities, which causes additional cost especially for non-motorised transport.

2.8.2. SEPARATION EFFECTS

Procedure for total and average costs

The estimates are based on a pilot survey for Zurich, where the levels and crossings are measured in detail. Also, results of EUROMOS (European Road Mobility Studies) have been used, especially data from Munich, Southampton and Madrid. For these cities, network length is available in detail. The results are transferred to other cities, using general indicators like the traffic volume and percentage of urban population. For this purpose, we use the population of cities with 50'000 inhabitants and more.

The estimation of separation effects of urban railway tracks is based on the same methodology. Railway tracks have about the same separation effect as an urban motorway, pedestrians need to take a longer way and loose therefore time. A detailed analysis of a model city (Zurich, see details in INFRAS/IWW (2000)) gives a rough database for a specific urban effect. Railway tracks in tunnels and on bridges are not relevant for this effect and are not accounted for.

This estimation for several European cities shows the following average unit costs, which were taken from INFRAS/IWW (2000) (price base year 1995) and adjusted to 2000 values using GDP deflators (OECD 2002). They have to be adjusted with the country specific adjustment factor.

› Road: 54.8 Euro per (urban) person and year

› Rail: 18.6 Euro per (urban) person and year.

Procedure for marginal costs

Separation costs depend directly on the traffic volume. Thus based on a waiting curve we assume that marginal costs are rising due to additional traffic. According to the model, only traffic on roads with a volume between 400 and 800 vehicles per hour can show marginal costs (roads with higher traffic volumes have too much traffic so that one additional vehicle would cause additional costs). For this traffic situation (volumes between 400 and 800 vehicles per hour), marginal separation costs are calculated, using an assumption for percentage of relevant traffic volume and of relevant daily hours.

2.8.3. SPACE AVAILABILITY FOR BICYCLES

Procedure for total and average costs

The methodology is again based on the previous study (INFRAS/IWW 2000) and main cost indicators as well as the number of the affected population were adjusted to 2000 values. It is important to notice that this approach (like the approach for nature and landscape) is related to the existing (road) infrastructure. It is an indirect proxy of the scarcity aspects in cities. Thus the approach is only relevant for the estimation of total and average costs. Using this approach, there are no short run marginal costs occurring.

The estimation of space availability for bicycles is used as a proxy for the scarcity of space in urban areas. They can be interpreted as compensation costs for scarce infrastructure for non-motorised transport. The aggregation to national cost for this urban effect follows the same methodology as for the separation effect. The projection to country wise total cost is made using an average value per (urban) affected person. This value was between 5 and 21 Euro per person and year for the four model cities in 1995. An average unit value of 12 Euro per urban person and year was adjusted to the year 2000 using GDP deflators (OECD 2002). The resulting value of 13.1 Euro per urban person and year has to be corrected with the country adjustment factor. Again, urban population are assumed to live in cities with more than 50'000 inhabitants.

Procedure for marginal costs

The scarcity costs expressed by additional space for bicycle lanes are partly depending on traffic volume. Since we just considered urban main roads which are usually quite crowded, an additional vehicle does not cause additional need for space. That means that in the short run these costs are close to zero. The argumentation however is similar as within the costs for nature and landscape. In the long run, if capacity is overused, additional space will be needed for new roads and for new bicycle lanes respectively. One could argue however, that a new road leads to a decrease of the existing space problem, leading as well to a decrease of the costs respectively. However there might be a trade off with other space problems in urban areas. Thus – in order to be in line with the approach for nature and landscape – we conclude that long term marginal costs are equal to average costs.[16]

2.9. UP- AND DOWNSTREAM PROCESSES

2.9.1. VALUATION APPROACH

Indirect effects of transport might cause additional external effects. The methodology to calculate additional external costs of up- and downstream processes is based on the INFRAS/IWW (2000) study. However, improved life cycle analysis data for some modes was available as well as new emission factors for all modes.

We can distinguish the following three important processes:

1. **Energy production** (precombustion): The production of all type of energy is causing additional nuisances due to extraction, transport, transmission. They depend directly on the amount of energy used. These effects are relevant for all transport means except the railways. Since the emissions of electricity production for railways operation are already considered within air pollution and climate costs, only risk elements (e.g. nuclear risks) are here considered in addition. These costs are also relevant in the short run.
2. **Vehicle production and maintenance**: The production of vehicles and rolling stock is important in the longer run, considering the life cycles of different transport means. Short run marginal costs are zero. These elements are causing especially additional emissions into the air, having an additional effect on air pollution and climate change costs.
3. **Infrastructure construction and maintenance**: The same arguments hold true for the infrastructure elements themselves. In the long run, additional emissions have to be considered here as well. They have to be treated similar to the aspects of nature and landscape discussed above, because they are attached to existing infrastructure and thus sunk costs. In contrast to those effects, up- and downstream effects happen especially during the construction phase (e.g. surface renewal).

16 Note that average cost are higher than expressed in the results chapter, since the costs estimated are not divided by national vehicle kilometre, but only by vehicle kilometres on urban main roads.

Although these processes refer to other nuisances already considered within this report (especially air pollution and climate change), it is useful to treat these up- and downstream effects separately, in order to increase transparency. The following effects will be distinguished:

- › Upstream effects as a percentage of air pollution costs, based on the amount of indirect effects of related emissions.
- › Upstream effects as a percentage of climate change costs, based on the amount of indirect processes of CO_2 emissions.
- › Nuclear Power risks for electricity production.

Basic eco-inventory data is taken from the Econinvent 2000 (see Ecoinvent (2003a+b). This data base provides up-to-date life cycle analysis data with related emissions of the most important green house gases and pollutants for many transport processes. The monetary values are based on the values used for air pollution and climate change costs. Specific shadow values used for the estimation of nuclear power risks are taken from INFRAS/Econcept/Prognos (1996).

2.9.2. PROCEDURE FOR TOTAL AND AVERAGE COSTS

The following figures present the approach to calculate external costs of up- and downstream processes as well as nuclear risks:

UP- AND DOWNSTREAM PROCESSES

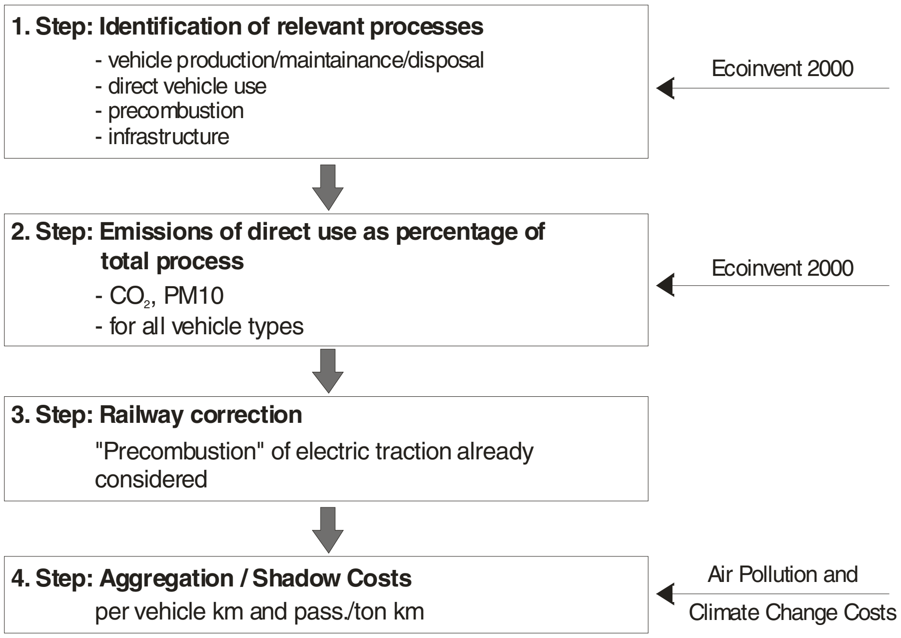

Figure 10 Procedure for the estimation of external costs of other up- and downstream processes

Regarding air pollution costs of up- and downstream processes, only PM10 emissions have been taken into account (previous study PM10 and NO_x) due to the fact that PM10 was the indicator pollutant of the air pollution cost calculation for all transport means. Due to its low mobility, the place where PM10 emissions occur is important. Upstream processes like mining for basic materials often take place in remote areas where very few people are affected by these emissions. The same is true for other processes in the life cycle. Therefore we weighted PM10 emissions of different up- and downstream processes with plausible factors in order not to overestimate air pollution costs.

Climate change costs of up- and downstream processes are calculated with the 'Climate Change Scenario High'.

EXTERNAL COSTS OF NUCLEAR RISKS

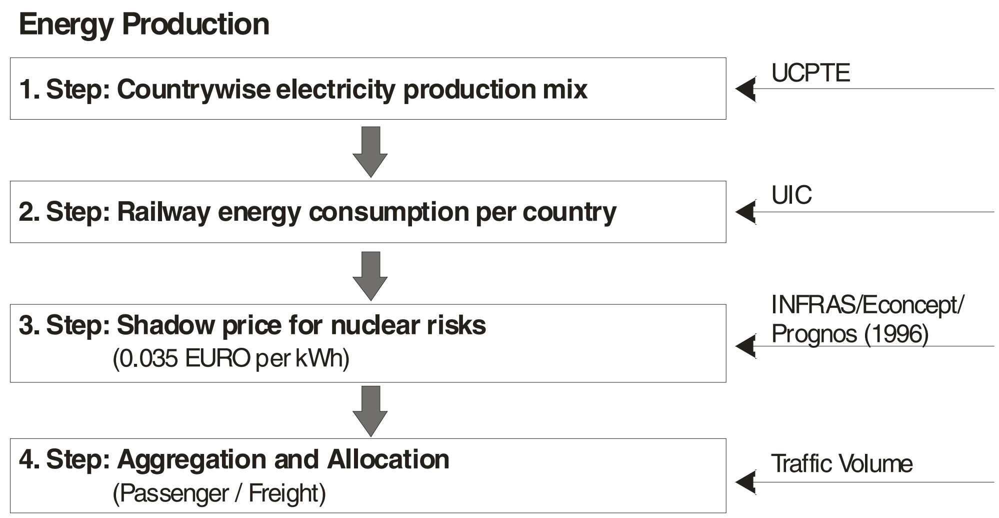

Figure 11 Procedure for the estimation of external costs of nuclear risks.

Based on the methodology described in the chapter of air pollution and climate change, specific shadow factors (according to the percentages of indirect emissions) are used in order to estimate external costs. The following table shows the most important relations.

SHADOW FACTORS FOR DIFFERENT UPSTREAM PROCESSES
IN % OF THE RESP. COST CATEGORY

	Air pollution (Percentage of air pollution costs)	**Climate change** (Percentage of climate change costs)
Passenger Cars	15%	21%
Buses and Coaches	16%	15%
Motorcycles	15%	21%
LDV	15%	18%
HDV	16%	15%
Rail Passenger	14%	30%
Rail Freight	14%	30%
Air Passenger	6%	2%
Air Freight	8%	3%
Waterways transport	22%	31%

Table 18 Used shadow factors for different upstream processes.

2.9.3. PROCEDURE FOR THE ESTIMATION OF MARGINAL COSTS

In the long run, all estimated costs are relevant, since production cycles are dependent on the traffic volume. Thus the estimated average costs will serve as a basis for the estimation of long run marginal costs. In the short run however, only additional costs of pre-combustion are important, since one can expect, that these costs vary directly with the use of energy. Thus short term marginal costs are based on the average costs of precombustion (air pollution, climate change costs and nuclear risks).

2.10. CONGESTION COSTS

2.10.1. GENERAL APPROACH

While all other cost categories considered in this study reflect the external costs imposed by transport on the whole of society, including inhabitants not participating in transport, congestion is a phenomenon within the transport sector. Users mutually disturb each other, but do not impose extra costs on the rest of society. Considering delays in freight or business transport, which entail additional production costs to certain industries, the shippers or the business traveller is assumed to account for these effects and thus they are not external. Therefore, congestion costs must not be added up with classical externalities.

The overall methodology for estimating congestion costs remains unchanged compared to the former study published in March 2000. In inter-urban road transport the analysis is based on traffic flow data by network sections provided by the European transport model VACLAV. Urban congestion is analysed by generalising the results of a number of available urban case studies. As in the 2000 study, the evaluation of these data bases will lead to three different indicators of road traffic congestion:

1. The "dead weight loss" as the neoclassical measure of the market inefficiency. This measure gives an indication of the savings in social costs which can be achieved by internalising user externalities.
2. An engineering-style delay measure, which compares actual user costs to a reference Level-of-Service. On the one hand this measure is arbitrary as there is no theoretical foundation of reference traffic conditions, but on the other hand it is easy to understand by non-economists.
3. Revenues expected from the internalisation of marginal social cost prices. This measure is closely linked to the dead weight loss as it gives an indication on how much money must be moved in order to get the social surplus calculated in (1).

Both, traffic data bases and the valuation of road traffic congestion have been substantially improved during the past three years. The new sources will be presented in detail in the following sub-sections.

Also in this update study the evaluation of traffic congestion is restricted to road traffic for two reasons: First we imply that in scheduled services, i.e. in rail and air transport, system operators try to optimise the use of existing capacity and thus delay externalities are already internalised. Second, for rail and air traffic no data on the relationship between traffic volumes and average delay times are available, and thus the dead weight loss can not be computed. However, the study will compile the UNITE country accounts, in which delay costs for several transport modes have been presented in order to give an impression on the order of magnitude of delays across modes.

2.10.2. VALUATION ISSUES

The costs affected by decreasing levels of service in road traffic are time costs and vehicle operating costs, where time consumption clearly represents the dominating cost element. In the UNITE project three recent studies on the valuation of travel time had been selected and compiled in order to receive a consistent valuation concept for the user cost and benefit case studies as well as for the valuation of traffic delays within the 18 country accounts. These cores studies are:

- The UK value of time study carried out by the Hague Consult Group in 1994 (Gunn and Rohr 1996).
- The 1995/1996 Value of Time study in the Netherlands, conducted by the Hague Consult Group (Gunn et al. 1999)
- The Swedish value of time study commissioned by the Swedish Institute for Transport and Communication Analysis (SIKA) and financed by the Swedish Communication and Research Board, the National Road Administration and the National Rail Administration (Algers et al. 1995, Algers et al. 1996).

Further information has been included on the values of freight transport of various modes (Joung 1996) and on air travel found by the EUNET project (Nellthorp et al. 1998). The results of the different studies were compiled by transport sector and were updated to 1998. Table 19 presents the comparison and the selected values for the UNITE project. For this study the UNITE values are applied after updating them to the year 2000.

Transport segment	HCG 1994 UK 1994	HCG 1998 NL 1997	HCG 1998 NL 1997	SIKA SE 1996	EUNET EU 1995	UNITE EU 1998
Passenger transport - VOT per person-hour						
Car / motorcycle		6.70		9.31		
Business	21.23	21.00		11.95		21.00
Commuting / private	5.53	6.37		3.91		6.00
leisure / holiday	3.79	5.08		3.10		4.00
Coach (Inter-urban)				7.47		
Business	21.23					21.00
Commuting / private	5.95			5.40		6.00
leisure / holiday	3.08			4.37		4.00
Urban bus / tramway				5.75		
Business	21.23					21.00
Commuting / private	5.95			4.94		6.00
leisure / holiday	3.08			3.22		3.20
Inter-urban rail		4.97		8.50		
Business		18.43		11.95		16.00
Commuting / private		6.48		6.21		6.40
leisure / holiday		4.41		4.94		4.70
Air traffic					40.60	
Business				16.20		16.20
Commuting / private				10.11		10.00
leisure / holiday				10.11		10.00
Freight Transport - VOT per vehicle, train, wagon, ship and ton-hour						
Road Transport	36.00					32.60
LDV	45.00			39.68	30.75	40.76
HDV	48.00			39.68	30.75	43.47
Rail transport						
Full trainload	801.00				645.37	725.45
Wagon load	32.00				26.16	28.98
Average per ton	0.83					0.76
Inland navigation						
Full ship load	222.00				178.55	201.06
Average per ton	0.20					0.18
Maritime shipping						
Full ship load	222.00				178.55	201.06
Average per ton	0.20					0.18

Table 19 Selected Studies on the valuation of travel time savings (Source: UNITE)

As this study will present the UNITE country results for delay costs in the rail and aviation sector, Table 19 contains congestion costs for all transport modes. According to the UNITE methodology these values are transferred to the different countries using GDP per capita figures. This approach will be modified according to the methodology used in this study by including national values on the purchasing power parity (PPP).

2.10.3. INTER-URBAN TRAFFIC DATABASE

Data on road traffic volumes and on road capacities is taken from the network database of the European transport model VACLAV. The database contains all motorways and most of other inter-urban roads, which are relevant for inter-regional traffic for 25 European countries. However, the network density varies considerably between the countries. While the digitised networks are very dense for Germany and the Benelux countries, southern Europe, the British islands, Ireland and the Scandinavian countries consist of only basic networks. This imbalance impacts the output of the congestion estimation to a high extend and must be considered carefully when interpreting the results. As the representation of the national motorway networks is equally good in the 17 countries considered in this study, the results are presented by road class to support the interpretation process.

The traffic volumes on the network are available for the categories passenger cars, buses and goods vehicles. They have been produced by the traffic generation, distribution and assignment module of the VACLAV model. For the calibration of these assignment results UN traffic counts in combination with national statistics on link-specific volumes and overall transport indicators had been used. Figure 12 depicts the network density of the VACLAV database.

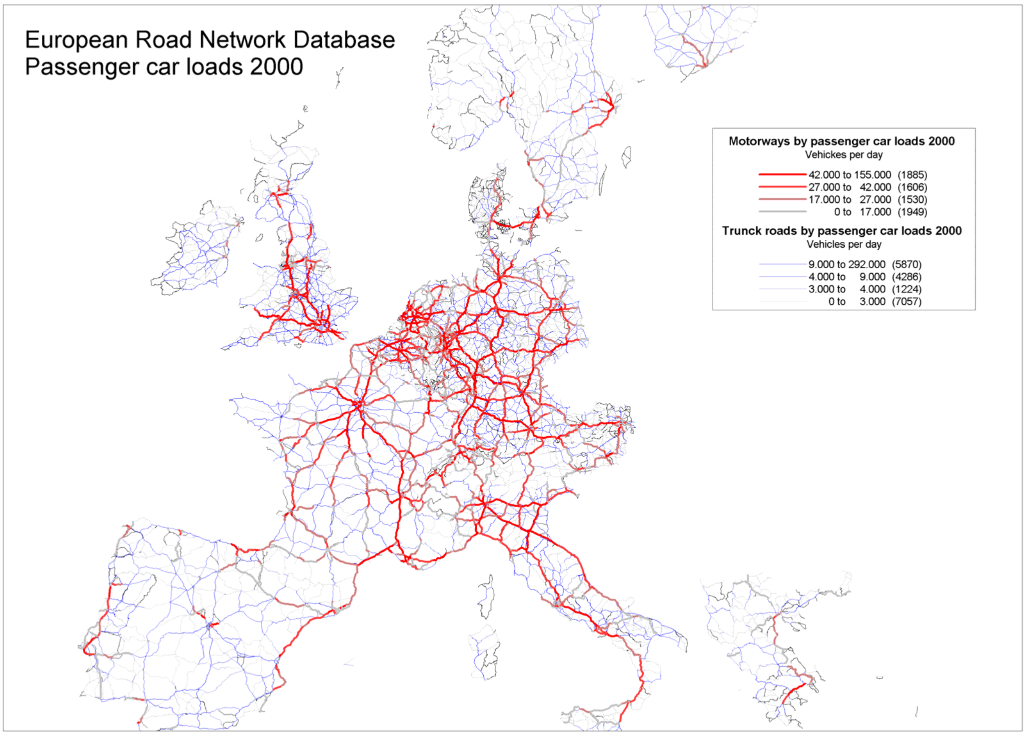

Figure 12 VACLAV traffic network and load database (Source: IWW)

The road links are encoded by the EWS road type, which is taken from the German manual for the economic assessment of road investment project EWS (FGSV 1997). This classification provides with the basic road type (motorway, trunk roads, urban collectors and local streets), the number of lanes per direction and the existence of emergency lanes. For these road types several sets of speed flow relationships exist, which allow to estimate the travel speeds for various vehicle classes as a function of traffic volume. The most recent speed-flow relationships in Germany are provided by the EWS manual, but in the federal investment plan 2003-2010 still the official functions defined in the 1980s are applied (FGSV 2001). Figure 13 compares these functions for a two lane motorway with the speed-flow curves provided by the UK COBA manual and with a TRENEN-style function (compare Proost et al. 1999). According to the German Manual on Road Design "HBS" (FGSV 2001) the quality of traffic can be described by six service levels (LOS) from "A" (no mutual interference of drivers) to "F" (congestion) as a function of traffic volume. Figure 13 depicts the LOS-classification of the EWS speed flow curve.

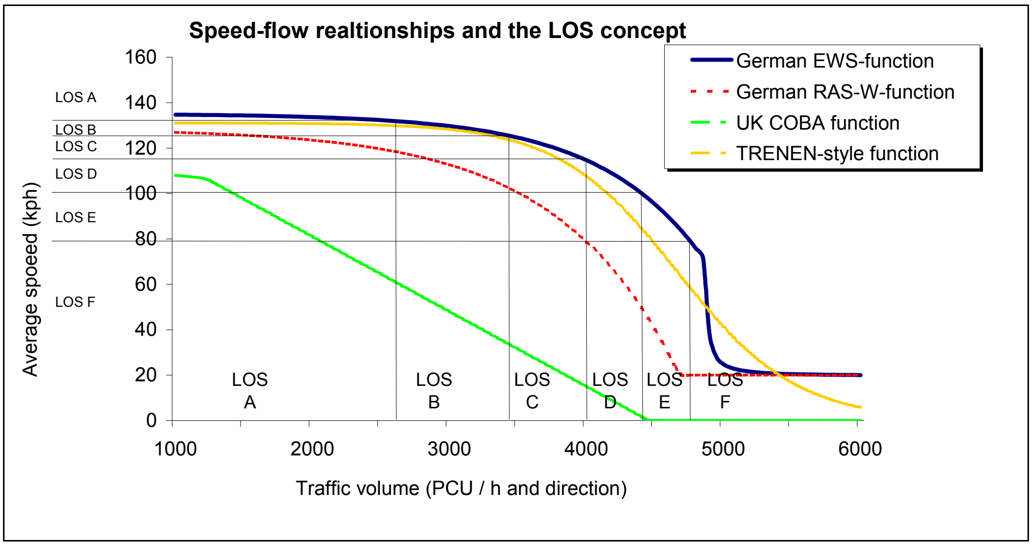

Figure 13 Travel speed and Level of Service for passenger cars on a three lane motorway using different speed-flow curves (Source: IWW)

Within this study EWS-functions are chosen as they represent the most recent best modern driving behaviour. Although it is acknowledged that across Europe drivers behave differently, for reasons of simplicity it is assumed that the EWS functions are more or less valid for in all countries investigated in this study. The transformation of the average daily traffic volumes provided by the VACLAV database into hourly traffic volumes is carried out using typical traffic patterns for each road type and for each vehicle category provided by the German Federal Highway Research Institute (BASt). From these patterns depicted in Figure 14 we select pattern B for passenger cars on motorways, pattern A for passenger cars on other roads and pattern D for goods vehicles on all inter-urban roads.

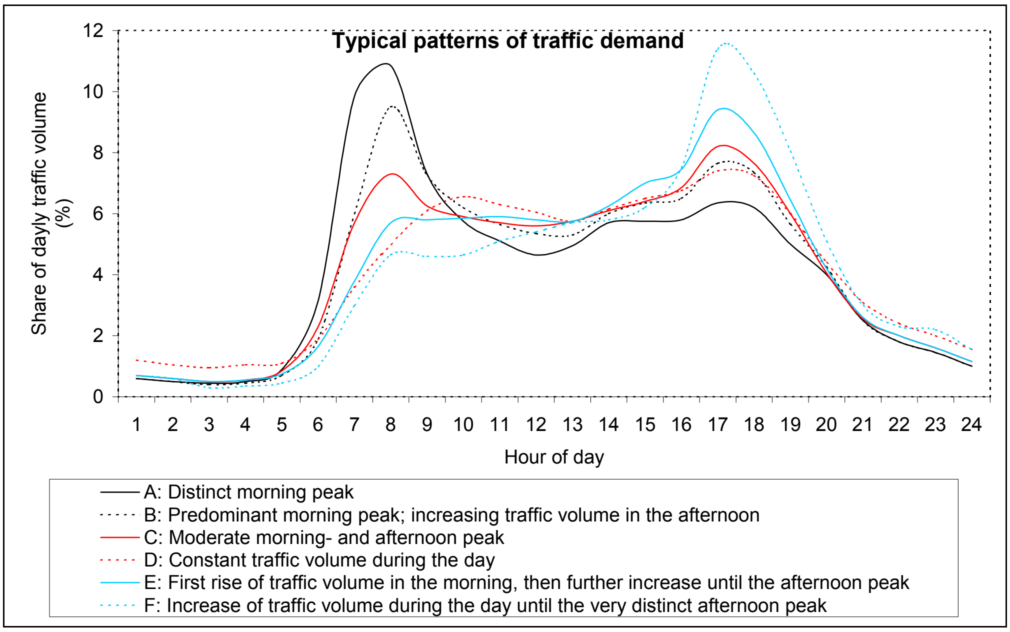

Figure 14 Typical traffic patterns in road transport

With this Information the network flow data can now be decomposed into vehicle kilometres per day in each LOS-cluster. For each service level the dead weight loss as the primary output of the congestion analysis is computed in time units per vehicle kilometre as described in the introduction to this section. Using the valuation of travel time and operating costs according to Section 2.10.2 and information on the mix of traffic types and travel purposes by road type and country, the overall dead weight loss per link can eventually be computed.

A further sensitive parameter for computing the dead weight loss is the elasticity of transport demand. As there are no new research results known, we use the value of -0.3 as had been done in the 2000-study. With this value, the actual traffic volume and the speed-flow relationships we now can compute the optimal traffic volume as the intersection of the demand function and the marginal social cost curve. The dead weight loss then results as the integral of the gap between the marginal social costs curve and the demand curve from the optimal to the actual traffic volume. This procedure is carried out for each link and each time segment.

The reference travel speed for estimating delay costs is determined by route search algorithms, which are available for tour planning in the internet. Here we find a reference travel speed of 120 kph on motorways and 60 kph on other inter-urban roads.
The expected revenues are computed as the difference between the marginal social costs and the average user costs at the optimal traffic volume times the optimal number of users.

2.10.4. URBAN CONGESTION

The methodology for estimating urban congestion costs used in this update study is somewhat different from the approach of the last study. First, the LOS concept is translated to urban roads using the respective speed-flow curves. The share of vehicle kilometres performed under each LOS cluster than is estimated by compiling the following data sources:

- The OECD investigation on sustainable urban transport, which contains data on travel speeds in some sample cities in peak and in the off-peak period (OECD 1995).
- The results of the four UNITE case studies on urban congestion in the morning peak traffic of Brussels, Helsinki, Edinburgh and Salzburg (UNITE 2002d).
- The share of vehicle kilometres performed under contested conditions in urban traffic reported by the UNITE country accounts.

In contrast to the detailed methodology carried out for motorways and other inter-urban roads, for urban congestion only two Level-of-Service conditions, which are "congested" (LOS-E) and "normal" (LOS-B) are distinguished.
Total traffic volumes in urban areas by vehicle type are derived from the TRENDS database for each country.

2.10.5. COST ALLOCATION

The allocation of total congestion costs to vehicle types is carried out by the concept PCE (Passenger Car Equivalent) factors. These factors are taken from latest research in Germany (Prognos/IWW 2002) and in the United States (FHWA 1997) and are used to weight each vehicle type's traffic volume in proportion to the road capacity occupied by it. The PCE-factors for goods vehicles vary between 1.5 for LGVs in urban areas and 3.5 for HGVs on inter-urban roads. The detailed values used in this study are shown in Table in the Annex to this report.

3. RESULTS 2000: TOTAL AND AVERAGE COSTS[17]

3.1. OVERVIEW: TOTAL AND AVERAGE COSTS 2000

The following tables and figures show the overall results of the update study. For a comparison with the results of the last study (INFRAS/IWW 2000) please refer to chapter 5.1 (page 107).

Accident and environmental costs 2000

The following figures present the results for total and average costs for 2000. **Total external costs** (excluding congestion costs, with climate change high scenario) amount to 650 billion Euros for 2000, being 7.3% of the total GDP in EU 17. Climate change is the most important cost category with 30% of total cost, if high shadow prices are used. Air pollution and accident costs amount to 27% and 24% respectively. The costs for noise and up- and downstream processes each account for 7% of total costs. The costs for nature and landscape and additional urban effects are of minor importance (5%). The most important mode is road transport, causing 83.7% of total cost, followed by air transport, causing 14% of total external costs. Railways (1.9%) and waterways (0.4%) are of minor importance. Two thirds of the costs are caused by passenger transport and one third by freight transport.

17 All figures in this chapter reflect the climate change high scenario (140 Euro per tonne of CO2).

TOTAL COSTS IN 2000 BY COST CATEGORY & TRANSPORT MODE														
[million Euro/year]			**Road**							**Rail**		**Aviation**		**Water-borne**
	Total	%	Car	Bus	MC	LDV	HDV	Pass. total	Freight total	Pass.	Freight	Pass.	Freight	Freight
Accidents	156'439	24	114'191	965	21'238	8'229	10'964	136'394	19'194	262	0	590	0	0
Noise	45'644	7	19'220	510	1'804	7'613	11'264	21'533	18'877	1'354	782	2'903	195	0
Air Pollu-tion	174'617	27	46'721	8'290	433	20'431	88'407	55'444	108'838	2'351	2'096	3'875	360	1'652
Climate Change High	195'714	30	64'812	3'341	1'319	13'493	29'418	69'472	42'911	2'094	800	74'493	5'438	506
Climate Change Low [1)]	*(27'959)*	*(4)*	*(9'259)*	*(477)*	*(188)*	*(1'928)*	*(4203)*	*(9'925)*	*(6'130)*	*(299)*	*(114)*	*(10'642)*	*(777)*	*(72)*
Nature & Landscape	20'014	3	10'596	276	233	2'562	4'692	11'105	7'254	202	64	1'211	87	91
Up-/Down-stream [2)]	47'376	7	19'319	1'585	335	5'276	16'967	21'240	22'243	1'140	608	1'592	170	383
Urban Effects	10'472	2	5'782	147	127	1'220	2'634	6'112	3'797	426	137	0	0	0
Total EU17 [3)]	650'275	100	280'640	15'114	25'491	58'824	164'346	321'301	223'114	7'828	4'487	84'664	6'250	2'632

Table 20 Total external costs of transport in the EU17 countries.
Remarks:
1) Climate change costs for the climate change low scenario with a shadow value of 20€/ t CO_2 (for information only, values not used to calculate total costs).
2) Climate change costs of up- and downstream processes are calculated with the shadow value of the climate change high scenario (140€/t CO_2).
3) Total costs calculated with the climate change high scenario.

TOTAL EXTERNAL COSTS 2000 (EXCLUDING CONGESTION)

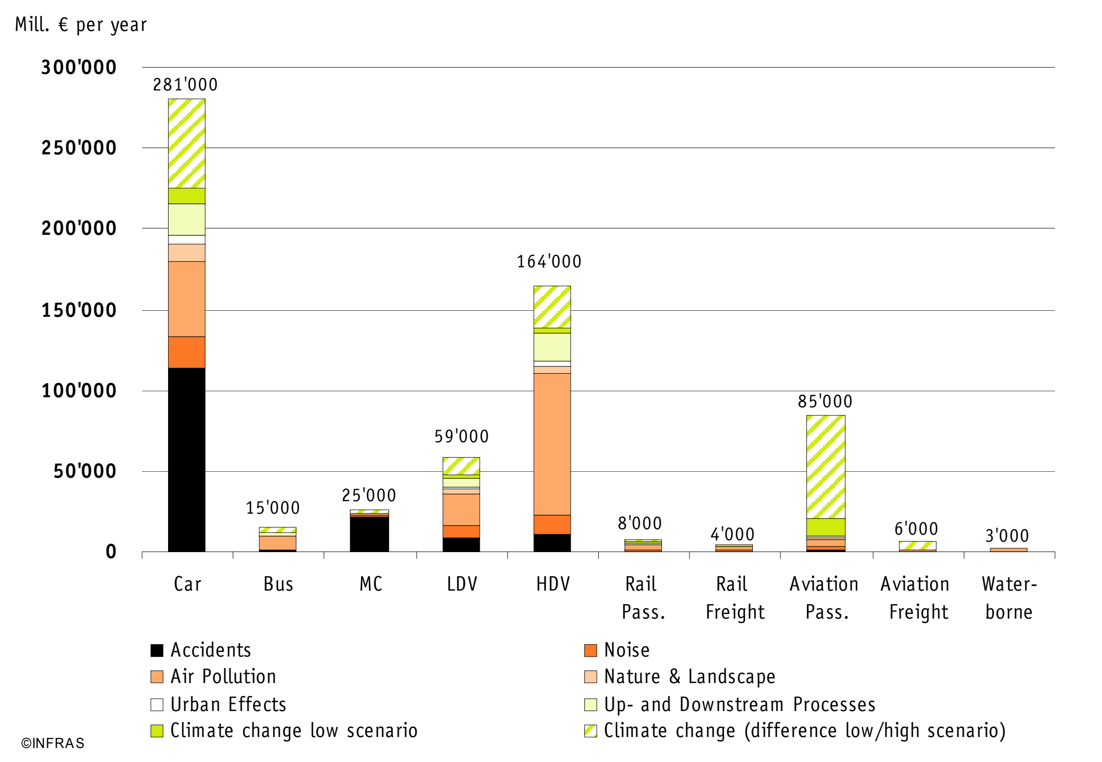

Figure 15 Total external costs 2000 (EU 17) by transport means and cost category.

Average costs are expressed in Euro per 1'000 pkm and tkm. Within the passenger transportation sector, passenger cars reach 76 Euro (high scenario). Railway costs amount to 22.9 Euro, which is 3.3 times lower than costs for the road sector. Most important for the railway sector are the effects on air pollution, climate change and noise. For the aviation sector, the predominant cost category is climate change.

AVERAGE COSTS IN 2000 BY COST CATEGORY & TRANSPORT MODE														
	Average Cost Passenger							**Average Cost Freight**						
	Road				Rail	Avia-tion	Over-all	Road			Rail	Avia-tion	Water-borne	Over-all
	Car	Bus	MC	Pass. total				LDV	HDV	Total				
	[Euro / 1000 pkm]							[Euro / 1000 tkm]						
Accidents	30.9	2.4	188.6	32.4	0.8	0.4	22.3	35.0	4.8	7.6	0.0	0.0	0.0	6.5
Noise [1)]	5.2	1.3	16.0	5.1	3.9	1.8	4.2	32.4	4.9	7.4	3.2	8.9	0.0	7.1
Air Pollution	12.7	20.7	3.8	13.2	6.9	2.4	10.0	86.9	38.3	42.8	8.3	15.6	14.1	38.5
Climate Change High	17.6	8.3	11.7	16.5	6.2	46.2	23.7	57.4	12.8	16.9	3.2	235.7	4.3	16.9
Climate Change Low[2)]	*(2.5)*	*(1.2)*	*(1.7)*	*(2.4)*	*(0.9)*	*(6.6)*	*(3.4)*	*(8.2)*	*(1.8)*	*(2.4)*	*(0.5)*	*(33.7)*	*(0.6)*	*(2.4)*
Nature & Landscape	2.9	0.7	2.1	2.6	0.6	0.8	2.0	10.9	2.0	2.9	0.3	3.8	0.8	2.6
Up-/Down-stream [3)]	5.2	3.9	3.0	5.0	3.4	1.0	3.9	22.4	7.4	8.8	2.4	7.4	3.3	8.0
Urban Effects	1.6	0.4	1.1	1.5	1.3	0.0	1.1	5.2	1.1	1.5	0.5	0.0	0.0	1.3
Total EU 17[4)]	76.0	37.7	226.3	76.4	22.9	52.5	67.2	250.2	71.2	87.8	17.9	271.3	22.5	80.9

Table 21 Average external costs of transport in the EU17 countries
Remarks:
1) The modal differences in noise costs are directly related to the national noise exposure databases used and thus might be subject to different ways of noise exposure measurement.
2) Average climate change costs for the low scenario (for information only, values not used to calculate total costs))
3) Climate change costs of up- and downstream processes are calculated with the shadow value of the 'Climate Change High Scenario'
4) Total average costs calculated with the climate change high scenario.
5) Noise costs for freight trains might be under-estimated as the simplified traffic allocation procedure applied did allocate most freight trains to daytime traffic.

AVERAGE EXTERNAL COSTS: PASSENGER 2000 (EXCLUDING CONGESTION)

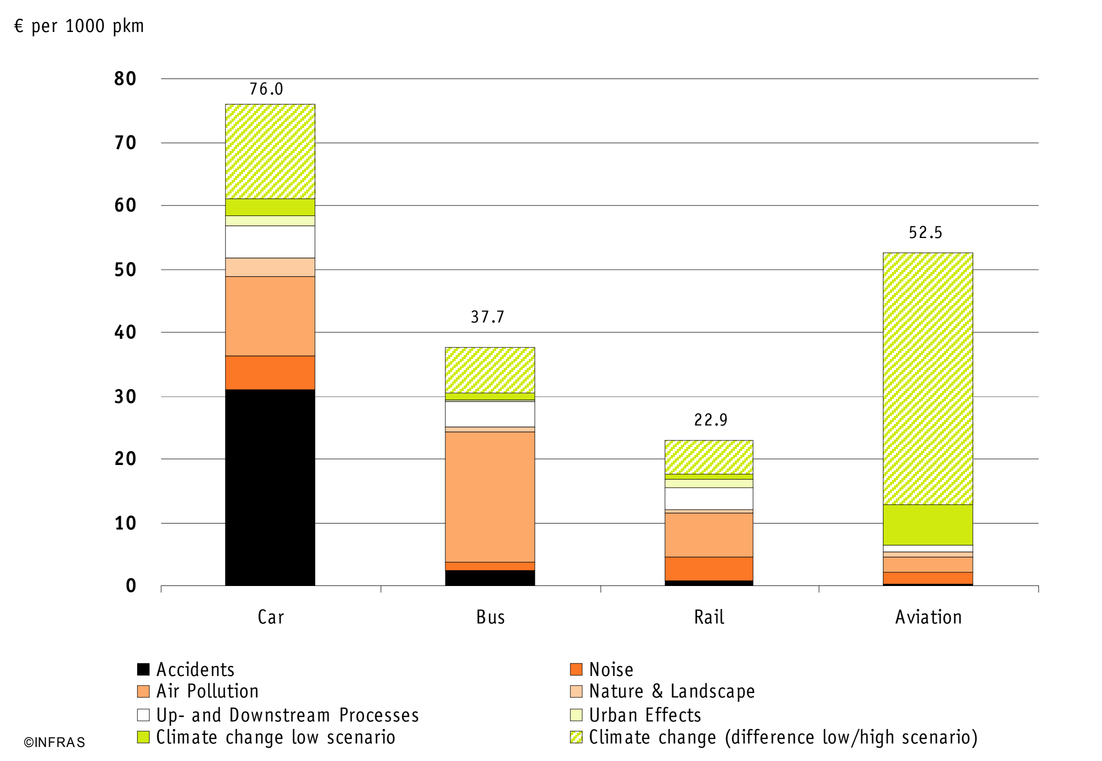

Figure 16 Average external costs 2000 (EU 17) by means of transport and cost category: Passenger transport. The high value of climate change costs in aviation is due to the higher global warming effect of aviation's CO_2 emissions at high altitude during flight (factor 2.5 used compared to the impacts of CO_2 emissions on the earth surface, based on IPCC 1999).

AVERAGE EXTERNAL COSTS: FREIGHT 2000 (EXCLUDING CONGESTION COSTS)

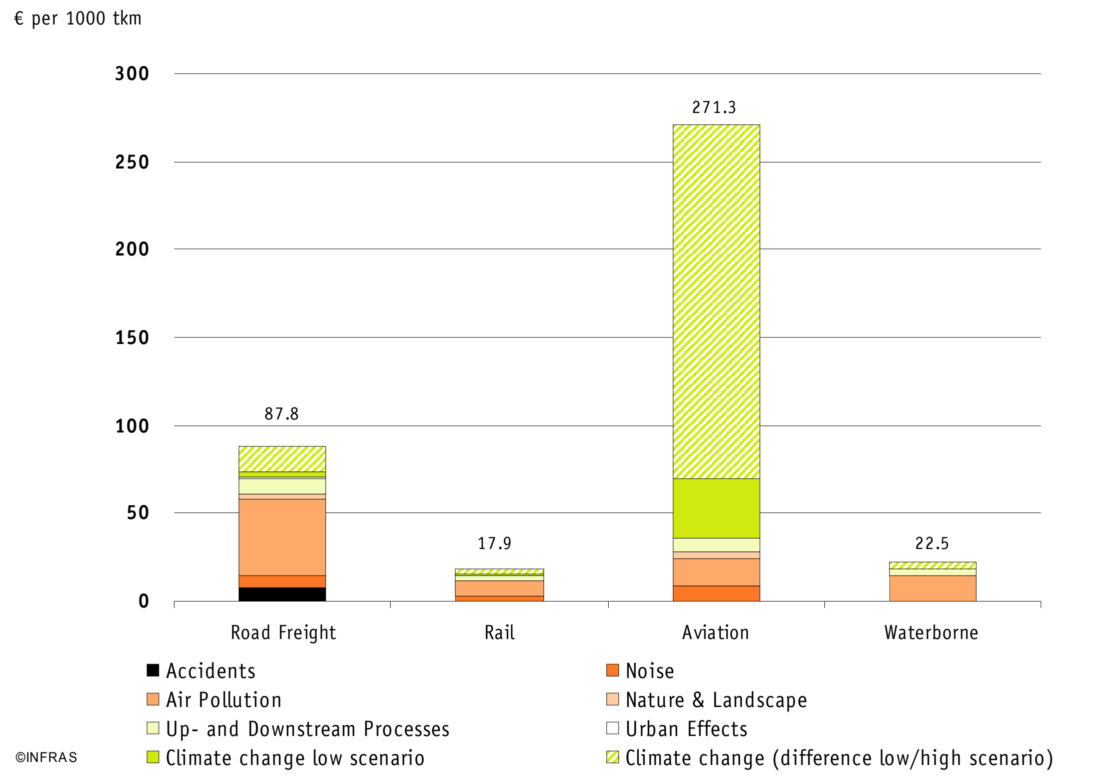

Figure 17 Average external costs 2000 (EU 17) by transport means and cost category: Freight transport.

In the **freight sector**, the average costs of air transport are significantly higher than the costs of all other means of transport. This is especially due to the fact that freight load (in tonnes) differs from mode to mode. Aeroplanes for example transport high quality freight of low specific weight. The costs for HDV (heavy duty vehicles) amount to 71.2 Euro per 1'000 tkm, which is 4 times higher than the cost for railways (Climate change high scenario).

The following tables and figures present results per country. Note that the accuracy level for disaggregated results in general is considerably lower than on aggregate (i.e. EU-level).

TOTAL COSTS IN 2000 BY COUNTRY & TRANSPORT MODE (UPPER BOUND)														
[million Euro/year]			**Road**							**Rail**		**Aviation**		**Wa-ter-borne**
	Total	%	Car	Bus	MC	LDV	HDV	Pass. total	Freight total	Pass.	Freight	Pass.	Freight	Freight
Austria	16'573	2.5	7'365	211	803	369	6'270	8'379	6'639	120	152	1'209	46	28
Belgium	22'293	3.4	10'884	261	348	1'500	5'846	11'493	7'346	243	125	2'482	451	152
Denmark	11'084	1.7	4'064	630	158	572	3'623	4'852	4'196	220	61	1'584	173	0
Finland	7'257	1.1	3'606	353	49	542	1'534	4'008	2'077	73	103	944	43	10
France	87'495	13.5	35'446	2'088	2'638	15'120	18'855	40'172	33'975	729	549	11'085	817	169
Germany	149'054	22.9	70'789	2'922	4'554	7'076	43'725	78'266	50'801	2'409	1'496	13'653	1'255	1'174
Greece	13'528	2.1	4'358	218	1'630	1'803	3'148	6'206	4'951	51	5	2'214	101	0
Ireland	6'831	1.1	2'641	190	88	430	2'132	2'919	2'562	40	19	1'220	70	0
Italy	95'238	14.6	42'073	2'466	9'918	7'199	24'937	54'457	32'137	1'064	490	6'730	355	4
Luxemb'g	1'566	0.2	681	54	28	31	443	762	473	16	18	129	155	12
Netherl.	30'468	4.7	9'679	388	669	33	10'947	10'736	10'979	363	51	6'428	835	1'076
Norway	7'860	1.2	3'758	400	160	496	1'468	4'319	1'965	87	60	1'383	46	0
Portugal	12'717	2.0	3'779	202	1'232	1'422	4'223	5'213	5'645	112	57	1'623	67	0
Spain	58'161	8.9	21'008	590	1'549	13'158	11'992	23'146	25'150	367	178	9'140	180	0
Sweden	13'686	2.1	6'375	669	177	909	3'359	7'221	4'267	93	182	1'803	120	1
Switzerl.	13'845	2.1	6'618	283	491	562	2'053	7'393	2'615	193	204	3'262	180	0
UK	102'619	15.8	47'580	3'191	986	7'564	19'773	51'758	27'337	1'649	737	19'776	1'356	6
EU17	650'275	100	280'640	15'114	25'491	58'824	164'346	321'301	223'114	7'828	4'487	84'664	6'250	2'632

Table 22 Total external costs of transport 2000 (EU 17) by country with shadow value for climate change of 140 €/t CO_2.

TOTAL COSTS IN 2000 BY COUNTRY & TRANSPORT MODE (UPPER BOUND)

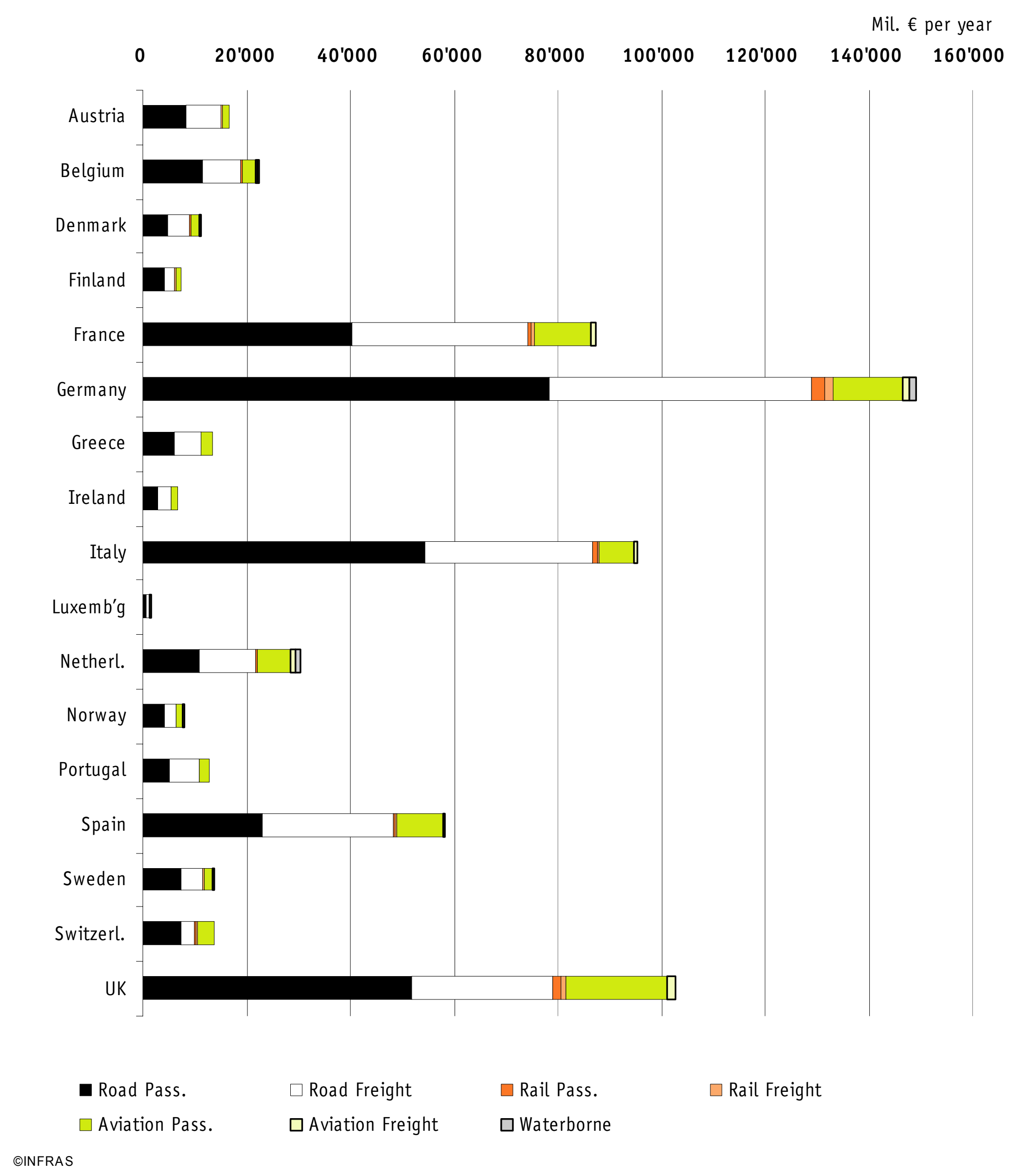

Figure 18 Total external costs of transport 2000 (EU 17) by country (shadow value for climate change: 140 €/t CO_2).

AVERAGE COSTS IN 2000 BY COUNTRY & TRANSPORT MODE (UPPER BOUND)														
	Average Cost Passenger							Average Cost Freight						
	Road				Rail	Aviation	Overall	Road			Rail	Aviation	Waterborne	Overall
	Car	Bus	MC	Pass. total				LDV	HDV	Total				
	[Euro / 1000 pkm]							[Euro / 1000 tkm]						
Austria	71.4	21.6	226.3	71.9	11.7	51.0	64.5	199.6	36.5	38.2	7.9	269.0	13.8	35.2
Belgium	140.8	27.2	278.2	130.4	27.5	49.9	96.9	267.4	83.6	97.2	16.8	263.6	23.2	89.0
Denmark	62.7	39.7	222.9	59.6	54.0	52.0	57.4	253.3	67.7	75.2	32.1	274.9	0.0	76.0
Finland	54.9	44.4	109.5	54.2	18.0	54.5	52.7	206.0	62.6	76.5	10.5	285.9	19.1	59.4
France	68.6	24.4	255.7	65.5	9.2	52.3	57.5	257.0	81.7	117.4	11.2	274.1	22.1	102.0
Germany	92.5	34.8	262.6	90.3	31.0	52.0	78.2	271.8	78.4	87.0	19.8	272.8	18.9	75.8
Greece	51.5	12.8	164.8	55.6	30.7	48.7	53.4	187.6	46.5	64.1	35.4	256.8	0.0	65.0
Ireland	94.3	64.6	290.0	93.4	22.9	57.4	77.0	296.8	65.0	74.8	45.9	303.6	0.0	76.0
Italy	73.7	43.1	212.0	80.7	21.5	58.1	74.1	270.6	78.6	93.4	29.9	297.4	34.8	91.2
Luxemb'g	141.4	127.9	369.8	143.6	32.2	26.9	87.5	322.9	121.6	126.7	27.3	140.6	38.2	113.8
Netherl.	92.5	36.8	293.2	91.4	28.6	56.8	72.0	230.8	75.5	75.6	22.2	299.8	28.6	69.6
Norway	75.0	98.9	216.9	78.7	33.5	59.2	71.6	673.6	118.6	149.8	24.6	309.7	0.0	131.8
Portugal	47.0	24.2	236.0	55.5	30.8	47.6	52.8	226.2	61.8	75.6	29.0	251.0	0.0	75.1
Spain	49.0	17.1	231.0	49.3	19.4	50.3	48.7	224.3	54.7	90.5	18.6	264.4	0.0	88.6
Sweden	64.0	77.8	143.3	65.9	18.0	53.9	61.5	197.4	85.9	97.7	10.9	284.9	0.0	75.2
Switzerl.	81.7	47.1	245.6	83.1	13.7	52.0	65.4	575.6	143.7	171.3	19.1	275.8	0.0	112.8
UK	84.0	82.3	260.1	85.0	34.9	51.9	70.6	263.3	71.0	88.9	28.8	273.7	30.6	87.1
EU17	76.0	37.7	226.3	76.4	22.9	52.5	67.2	250.2	71.2	87.8	17.9	271.3	22.5	80.9

Table 23 Average external costs 2000 (EU 17) by country (shadow value for climate change: 140 €/t CO_2).

3.2. RESULTS 2000 PER COST CATEGORY

3.2.1. ACCIDENT COSTS

While total accident costs almost remain unchanged, average external accident costs decrease significantly due to increasing traffic volumes. Average external accident costs decrease in road passenger transport by 8% and in rail passenger transport by 22%.

ROAD ACCIDENT FATALITIES 1995 AND 2000

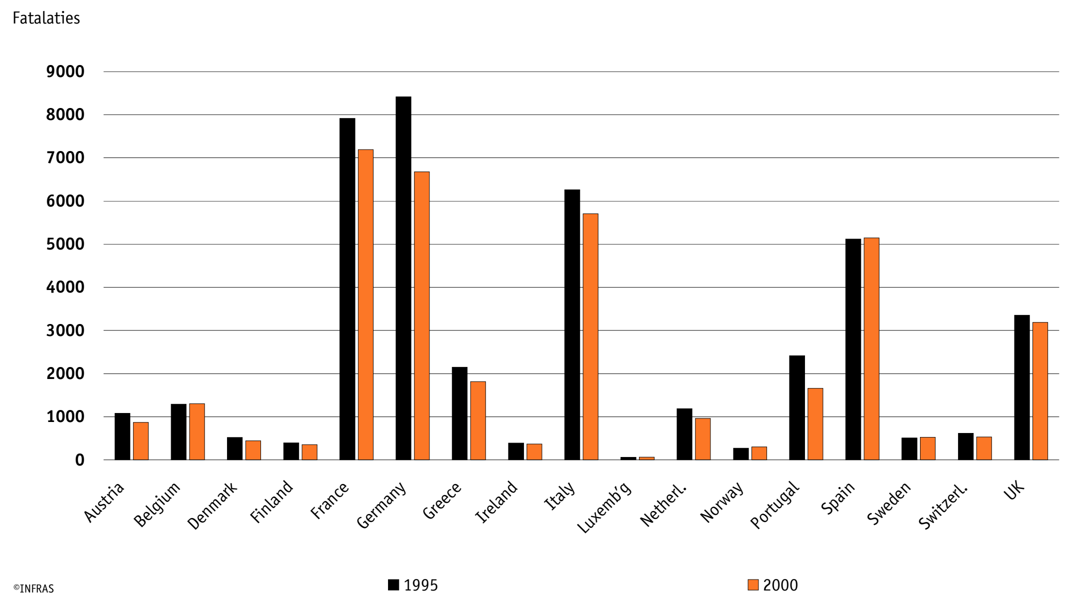

Figure 19 Values based on IRTAD, excluding casualties caused by non-motorised transport.

RAIL ACCIDENT FATALITIES 1995 AND 2000

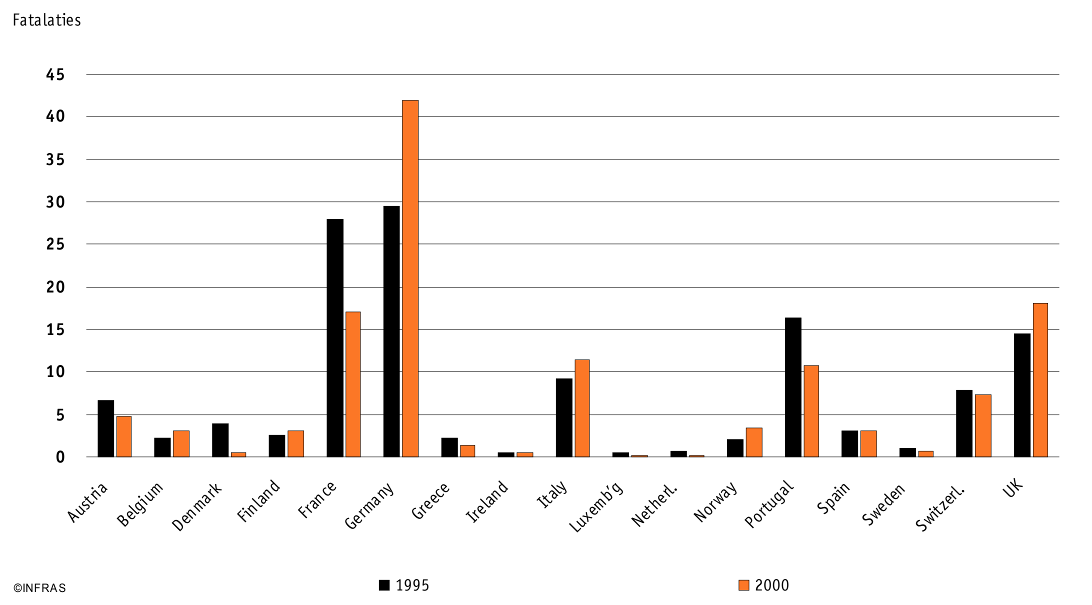

Figure 20 Fatalities based on a seven years average (1995: 1991-1997, 2000: 1994-2000). The noticeable increase of fatality numbers in Germany is caused by the ICE accident in Eschede in 1998 (with 101 victims).

Overall accident costs increased between 1995 and 2000 by 0.5% although the number of fatalities decreased in the same period by 12%. The most important reasons for this development are:

- Increasing numbers of severe injuries,
- Higher Net production losses (in line with growth of GDP per capita),
- Increase of additional external costs (costs for medical care, replacement costs, administrative costs, etc.) in line with growth of GDP per capita.

3.2.2. NOISE COSTS

In comparison to the previous study (INFRAS/ IWW 2000) the total external noise costs have increased drastically (+25%). While in the previous study about 36 billion Euros were accounted for total external noise costs of transport, in the actual study about 46 billion Euros were calculated. The results by transport mode show, that the noise costs of the rail-ways have grown marginally by 10%, whereas the costs calculated for road and aviation have increased drastically (road: +26% and air: +23%). The allocation to vehicle types within the modes has altered only slightly due to changes in traffic volumes.

The marginal increase of external railway noise costs is partly due to the technical improvements introduced by railway companies and track operators (new vehicle fleet, noise protection measures etc.). However, it must be considered that the database of inhabitants exposed to transport noise has been substantially altered for some countries, and that the changes in total noise costs are thus due to methodological improvements. This holds in particular true for the drastic increases of external noise costs faced by road and air modes.

The reasons for the drastic increases in road and aviation noise costs can be explained as follows:

- (1) Besides the willingness to pay (WTP) and the valuation of mortality and morbidity used for the 1995 and 2000 studies, this study takes into account the medical costs, which are caused by traffic noise above 65 db(A). These costs are mainly allocated to road traffic as the share of inhabitants exposed to railway noise above 65 dB(A) is comparably low.
- (2) The data basis is improved with up-to-date national and international studies on noise concernment (e.g. WHO). In the previous study for some countries (e.g. Italy) noise concernment was calculated by exponential smoothing. Most of these data gaps (esp. for rail and road) can now be filled and thus give a more realistic picture of the

real situation of noise exposure. In most cases the values, used in the old study, for the exposed population by railway noise were too high, while in a number of countries the share of population exposed to road and air traffic noise turned out to be too low.

For some modes, average external noise costs in passenger and freight transport are drastically lower than in the previous study. This development, which is particularly obvious for aviation, is driven by the increase of transport volumes on the European traffic network between 1995 and 2000.

There are also side measures, which influence this development, e.g.:
- Better noise protection (e.g. sound insulating windows) and
- New European noise legislatives (improved noise standards).

3.2.3. AIR POLLUTION COSTS

Within passenger transport, cars amount to 12.7 Euro/1'000 pkm, which is ca. 1.9 times higher than rail transport. This relation has improved towards road transport due to the fact that more and better information regarding non-exhaust emission factors of passenger road transport was available. Within freight transport, air pollution costs of HDV are more than 4.5 times higher than rail transport.

In comparison with 1995 total Air Pollution costs increase by ca. 30%. The main reasons are:
- Decreasing exhaust emissions but increasing non exhaust emissions (in line with transport volume),
- GDP adaptation of Willingness to pay values per additional case (+9.5%) with the exception of the risk value.
- Population growth (+1.3%),
- New interpretation of the relevant cost factors of the WHO-study (WHO 1999a-d). The costs factors in this study correspond more to European values than to Swiss values. As a consequence the value transfer procedure has to be modified (EU=100 instead of Switzerland=100).

3.2.4. CLIMATE CHANGE COSTS

Comparing the average climate change costs, the following comments can be made:[18]

- Within passenger transport, cars amount to 17.6 Euro/1'000 pkm (upper bound for shadow value), which is a little higher amount as the air pollution costs. The values for rail passenger transport are about one-third of road passenger transport. The values resulting for air passenger transport are similar to those of passenger cars.
- Within freight transport, the average values for HDV are more than 4 times higher than the values for rail transport. Very high values (about 14 times higher than road freight transport) result for air freight transport. Here as well we have to consider that the indicator (tonnes) is not really comparable, since products of higher value are usually transported by air. Waterborne transport also produces rather low costs per tonne kilometre, it being roughly 1 Euro per 1000 tkm higher than rail transport.
- The differences between the countries also mainly depend on the vehicle park (age and environmental performance of the park, share of diesel) and the national electricity mix (for the rail sector).

Table 24 shows the increase in total vehicle kilometres between 1995 and 2000. CO_2 emissions depend directly on the fuel resp. energy consumption of a vehicle. This means that more traffic – expressed in vehicle kilometres – leads to more emissions. On the other hand, improved fuel efficiency lead to a decrease in energy consumption within road transport over the last years. In the period between 1996 and 2001 fuel consumption of passenger cars in Europe decreased by around 2.1% per year (BFE 2003).

INCREASE OF VKM BETWEEN 1995 AND 2000

	Road		Rail	Aviation
	Pass. total	Freight total	Total	Total
EU17	+12%	+16%	+7%	159% 1)

1) Load Factor Aviation EU17: 141 persons per aircraft

Table 24

This trend leads finally to higher total costs whereas average costs remain more or less in the same range for 2000 compared to 1995.

18 Climate change high scenario.

Another reason for higher total costs is that the upper bound of avoidance costs is 140 € per ton CO_2 compared to 135 € per ton CO_2 in INFRAS/IWW 2000, which is about 3.7% more.

3.2.5. COSTS FOR NATURE AND LANDSCAPE

The total external costs for nature and landscape are, compared to other cost categories (e.g. climate change, etc.), very low. Road transport has more than 90% of all arising total costs for nature and landscape, because of the growing road net in Europe. The countries France, Germany and Italy cover more then 50% of the costs.

Comparing the average costs, the following comments can be made:
› Within passenger transport, cars amount to 2.86 Euro/1'000 pkm, which is about 5 times higher than rail. One main reason is that road infrastructure has increased significantly between 1950 and today, whereas rail infrastructure remained rather stable.
› Within freight transport, the relation is even more in favour of rail. Rail costs are even lower than waterborne transport, since – as with road transport – the infrastructure for waterborne transport has increased within the last decades.
› The differences between the countries are mainly based on the increase of infrastructure between 1950 and today on the one hand and the loading factors of infrastructure on the other hand.

3.2.6. ADDITIONAL COSTS IN URBAN AREAS

Total additional costs in urban areas are with a share of 2% of total external costs a cost category of minor importance. Road transport contributes to 95% of total external costs in urban areas whereas rail transport is responsible for the remaining 5%. Within the cost category separation costs are of major importance with a share of over 81%. Regarding average costs the following can be stated:
› Within passenger transport, additional costs in urban areas have the same level for passenger cars and rail (average costs for rail transport are ca. 14% lower). This is due to the fact that the detours due to railway lines are bigger, although the absolute amount is much lower. However the space availability for bicycle lanes is only relevant for road transport. They are only relevant locally. The national average values are rather low.
› Within freight transport, the average costs of HDVs are 55% times higher than the costs for freight rail. No costs are occurring for the other transport means.

› The differences between the countries are mainly based on the amount and the share of urban transport. Thus countries like the Netherlands, UK and Germany have rather high average costs (for urban population figures refer to Table 45).
› In comparison to 1995 total external costs for additional urban effects increase by 18%. This is mainly due to the adaptation of unit cost factors and an increase of urban population.

3.2.7. UP- AND DOWNSTREAM PROCESSES

Most important are upstream processes for climate change costs, mainly based on the use of fossil energy for the construction of vehicles and infrastructure. They amount to 52% of total costs, whereas the air pollution costs amount to 48%. Nuclear power risks have a minor share, but are of special interest to rail transport. They amount to 0.36 billion Euro. Comparing the average costs, we can state the following important results:
› Within passenger transport, upstream effects are higher for passenger cars than passenger rail, whereas the costs for air transport are significantly lower. Nuclear power risks are important for rail and amount to 17–23% of average costs.
› Within freight transport, rail has about 33% of the costs of HDV. The share of nuclear power risks is similar to those in passenger transport. Whereas the costs for waterborne transport are very low, the high level for air freight transport occurs due to the low loading factors.
› The differences between the countries are mainly based on the amount of mileage and initial air pollution and climate costs. The nuclear power risks are directly based on the railways share of electricity production mix.
› Compared to 1995 cost for up- and downstream processes decreased by 16%. The main reason for that is the new life cycle assessment data (Ecoinvent 2003a+b). In addition reduction factors for PM10 emissions of up- and downstream processes have been introduced because the population is exposed to a lower degree to these emissions which often occur in remote areas.

3.2.8. CONGESTION COSTS

The deadweight loss as the economic measure of total congestion costs, is roughly twice as high (63 billion Euro) as the figure presented in the 2000 study (33 billion Euro). The reason for this drastic increase is a methodological one, as

› (1) the networks of the VACLAV traffic model are more dense than the ones used in the 2000 study and
› (2) Traffic volumes, which are not considered by the VACLAV model, had been included here.

The highest share of total costs is calculated for Germany, which is on the one hand caused by the high traffic volumes on the German network, but also by the high quality of the digitised road network used by the transport model. Also road freight transport accounts only for around 20% of traffic demand, its congestion costs are close to those of passenger vehicles. This fact can be explained by the comparably high use of road capacity by freight vehicles.

Besides the deadweight loss, the expected revenues from charging road traffic for congestion and delay costs, which express the additional resource consumption of transport, compared to a selected reference speed, have been calculated. The results obtained by using the European transport model VACLAV are presented in Figure 21. It shows that the deadweight loss as the real economic measure of congestion is only 8% to 10% of the charging revenues, which reflect the total amount of money to be moved in order to remove the deadweight loss. Assuming that the charge collection is associated with 5% to 15% of transaction costs it gets obvious, that the social surplus expected from the internalisation of congestion costs ranges in the same order of magnitude of the costs associated with its achievement. Thus, the area-wide introduction of congestion charging systems in whole Europe gets questionable. However, in dense traffic areas the efficiency of such systems might be more favourable.

DEADWEIGHT LOSS, CHARGING REVENUES AND DELAY COSTS IN ROAD TRANSPORT 2000

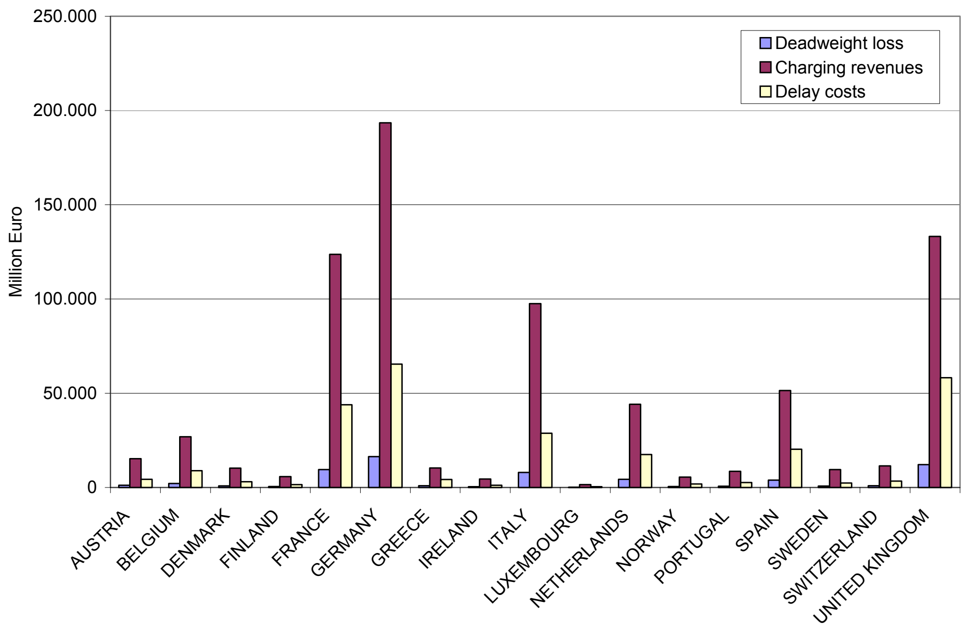

Figure 21 Comparison of different congestion cost measures for 2000

The deadweight loss concept can not be applied to scheduled transport as in this case capacity is allocated by a central authority and thus congestion costs are not entirely external. However, the UNITE study has concluded with a number of delay cost figures for some European countries. They have been defined in a very cautious way in order to approach the deadweight loss measure as good as possible. The comparison in Table 25 shows that (1) the differences of the two values for the big countries in road transport are in most cases minor and that (2) the delay costs for rail and air transport together range at about 1% to 5% of road delay costs. However, these results must be considered with care as the methodology applied was not unique in the different country accounts.

TOTAL COSTS IN 2000 BY COUNTRY & TRANSPORT MODE				
[million Euro/year]				
Country	This study Deadweight loss 2000 values in 2000 prices	UNITE country accounts Delay costs (1998 values in Euro 1990)		
	Road	Road+PT	Rail	Air
Austria	1'224	1.589	25	57
Belgium	2'186		32	
Denmark	814	407	9	119
France	9'500	20.268	133	1.090
Germany	16'354	17.506	682	147
Greece	931	5.239	36	47
Ireland	337	401		
Netherlands	4'263	3.103	45	89
Portugal	666	141		8
Spain	3'880	3.726	10	249
Sweden	761		63	21
Switzerland	936	651	65	132
UK	12'108	19.371	185	581

Table 25 Comparison to the results of the UNITE country accounts

Average external congestion costs are computed by dividing the deadweight loss per user group by its traffic volume. In passenger transport they are 56% higher than in the previous study. Besides the increase of transport volumes on the European road network between 1995 and 2000, this development is driven by the improved representation of urban traffic conditions and by the more detailed encoding of the inter-urban road networks within the VACLAV transport model.

In general the average cost results draw a realistic picture of the European road network conditions, in that the areas along the "Blue Banana" (southern England, the Benelux countries, Germany to northern Italy) show comparably high average cost results.

4. MARGINAL COSTS IN DIFFERENT TRAFFIC SITUATIONS

4.1. OVERVIEW: AGGREGATED RESULTS

The following table shows the values (the ranges respectively) for all cost categories. The ranges are quite significant, since different vehicle categories, countries and traffic situations are considered.

AGGREGATED RESULTS: MARGINAL COSTS											
€/1000 pkm/tkm		**Road**					**Rail**		**Aviation**		**Waterborne**
		Car	Bus	MC	LDV	HDV	Pass.	Freight	Pass.	Freight	Freight
Accidents	Marginal	10-90	1-7	36-629	10-110	0.7-11.8	-	-	-	-	-
	Average	30.9	2.4	188.6	35.01	4.75	0.74	-	0.37	-	0
Noise [1)]	Marginal	0.07-13	0.05-4.6	0.25-33	2.4-307	0.25-32	0.09-1.6	0.06-1.08	0.1-4.0	0.3-19.0	0
	Average	5.2	1.3	16.0	32.4	4.9	3.9	3.2	1.8	8.9	0.00
Air Pollution	Marginal	5.7-44.9	12-18	3.2	15-100	33.5	5.1	7.4	0.2	1.8	8.8
(only health costs)	Average	10.1	16.9	3.3	77.6	34.0	5.1	7.4	0.2	1.8	8.8
Climate Change	Marginal	1.7-27	0.7-9.5	1.7-11.7	8.2-57.4	1.8-12.8	0.3-7.1	0.4-5.3	6.6-46.2	33.7-235.7	4.3
	Average	17.6	8.3	11.7	57.4	12.8	5.9	3.2	46.2	235.7	4.3
Nature & Landscape	Marginal	0-2.1	0-1.3	1.9	10.9	0.8	0.7-1.2	0.1	1.1	6.5	0.8
	Average	2.87	0.69	2.07	10.90	2.03	0.58	0.26	0.75	3.77	0.78
Urban effects	Marginal	1.1-9.6	0.1-2.2	0.7-7.1	3.0-32.3	0.9-7.1	0	0	0	0	0
	Average	1.6	0.4	1.1	5.2	1.1	1.3	0.5	0	0	0
Up- and down-	Marginal	2.0-4.1	2.6-6.0	1.3-2.7	13.0-23.4	3.6-7.4	0.9-8.3	0.2-1.7	0.8-0.9	6.3-8.1	0.8-1.8
stream processes	Average	5.2	3.95	2.98	22.44	7.36	3.22	2.44	0.99	7.38	3.27

Table 26 Marginal costs by cost category and transport mean (the ranges reflect different vehicle categories (petrol, diesel, electricity) and traffic situations (urban, interurban). For urban effects ranges show different marginal costs of space availability and (low values) and separation costs (high values). For comparison average values as shown in chapter 3 are presented for each cost category**.**
Remarks:
1) Average and marginal noise costs are measured by different methods and thus are not fully comparable. The marginal values are to be understood as ranges of usual costs. Considerably higher or lower values are possible in particular cases.

If we compare average and marginal costs, the following general conclusions can be drawn:

- The level of marginal and average cost is comparable. Marginal costs are much more differentiated, since they relate to different traffic situations and types of vehicles.
- Most important for the order of magnitude of marginal accident costs are the assumptions concerning the level of internalisation of the accident risk.
- Due to their decreasing cost function marginal noise costs fall below average costs for medium to high traffic volumes. However, in road and air traffic they may exceed average costs since roads frequently lead through settlements and the alternation of traffic loads over day vary considerably between the modes. The same holds for airports, where approach paths often lead directly over housing areas.
- For air pollution, average values are basically similar to marginal values due to linear dose response functions and model calculations. There are big differences between different vehicle categories.
- For climate change, average costs are equal to marginal costs. The ranges stem from different vehicle categories.
- For nature and landscape, average costs are close to maximum marginal costs. This is plausible since marginal costs are mostly relevant only in the long run.
- Marginal costs of urban effects are generally higher than average costs. Both values should be compared carefully since marginal costs are calculated using only urban traffic volumes while average costs are calculated with national traffic volumes. Marginal separation costs are significantly higher than marginal space availability costs.
- For up- and downstream processes marginal costs are mainly related to precombustion processes. Therefore marginal costs are generally lower than average costs which include as well vehicle and infrastructure related processes (production, maintenance and disposal of rolling stock and infrastructure). Thus average costs are close to long run marginal costs.

The following chapters present more detailed results per cost category.

4.2. RESULTS 2000 PER COST CATEGORY

4.2.1. ACCIDENT COSTS

Marginal external accident costs are the costs induced by an additional vehicle kilometre. There are four important influencing factors for external accident costs:

- the costs of an accident,
- the accident risk,
- the proportion of the cost already born by the user,

› the risk elasticity (change in risk as the traffic volume changes).

We distinguish between accidents on motorways, on inter-urban roads and in urban areas. In the IRTAD database on road accidents in Europe was used to calculate average costs which are the basis for the estimation of marginal costs. Due to data availability (lack of differentiation in the IRTAD database as well as missing values for specific countries and years) a number of estimations had to be made.

› The IRTAD database is incomplete and many data (accident distribution as well as vehicle kilometre on different road types) have to be estimated
› Marginal costs are split to the road modes by using the same distribution as average accident costs.

The following table shows the range of marginal accident costs for medium traffic flows in selected countries.

RANGE OF MARGINAL ACCIDENT COSTS FOR MEDIUM TRAFFIC FLOWS
€ PER 1'000 PKM / TKM

	Motorways						Inter-urban Roads						Urban Roads					
	Cars			HDV			Cars			HDV			Cars			HDV		
	low	mean	high	low	mean	high	low	mean	high	low	mean	high	low	mean	high	low	mean	high
Austria	9.4	18.0	22.4	0.8	1.5	1.9	24.1	27.6	33.9	2.0	2.3	2.9	34.1	35.2	36.2	2.9	3.0	3.1
Belgium	11.3	21.7	27.1	1.2	2.4	2.9	60.3	69.0	84.9	6.4	7.3	9.0	122.6	126.4	130.2	11.2	11.6	11.9
Denmark	3.6	6.8	8.5	0.4	0.8	1.0	20.3	23.2	28.5	2.4	2.7	3.4	50.7	52.3	53.9	5.4	5.6	5.8
Finland	3.5	6.8	8.5	0.5	0.9	1.1	20.5	23.5	28.9	2.7	3.1	3.8	6.8	7.0	7.2	0.9	0.9	1.0
France	4.1	7.8	9.8	1.0	1.8	2.3	24.9	28.5	35.0	5.8	6.6	8.1	33.5	34.6	35.6	6.7	7.0	7.2
Germany	5.1	9.7	12.2	0.8	1.5	1.9	34.9	39.9	49.2	5.3	6.1	7.5	87.3	90.0	92.8	11.4	11.8	12.1
Ireland Rep.	8.0	15.3	19.1	1.0	1.9	2.4	13.8	15.8	19.5	1.8	2.0	2.5	42.7	44.0	45.4	5.4	5.6	5.8
Nether-lands	3.8	7.4	9.2	0.5	0.9	1.1	34.4	39.3	48.4	4.1	4.7	5.8	93.5	96.4	99.3	9.8	10.1	10.4
Sweden	2.4	4.7	5.9	0.4	0.7	0.9	17.0	19.4	23.9	2.5	2.9	3.5	12.1	12.5	12.9	1.8	1.8	1.9
Switzer-land	3.0	5.9	7.3	0.6	1.1	1.3	31.3	35.8	44.1	5.8	6.6	8.1	35.5	36.6	37.7	6.5	6.7	6.9
UK	4.8	9.2	11.5	0.6	1.1	1.3	28.9	33.1	40.7	3.3	3.8	4.7	33.2	34.2	35.2	3.8	3.9	4.0

Table 27

To improve comparability with other studies, marginal costs are expressed in € per 1'000 vehicle kilometre in the following table:

RANGE OF MARGINAL ACCIDENT COSTS FOR MEDIUM TRAFFIC FLOWS € PER 1'000 VEHICLE KILOMETRE																		
	Motorways						**Inter-urban Roads**						**Urban Roads**					
	Cars			**HDV**			**Cars**			**HDV**			**Cars**			**HDV**		
	low	**mean**	**high**	**low**	**mean**	**high**	**low**	**mean**	**high**	**low**	**mean**	**high**	**low**	**mean**	**high**	**low**	**mean**	**high**
Austria	14.2	27.3	34.1	8.7	16.6	20.7	36.7	41.9	51.6	22.3	25.5	31.4	51.8	53.5	55.1	31.6	32.5	33.5
Belgium	11.3	21.7	27.1	7.5	14.4	18.0	60.3	69.0	84.9	39.1	44.7	55.0	122.6	126.4	130.2	69.0	71.1	73.3
Denmark	6.3	12.1	15.1	4.0	7.6	9.5	35.8	40.9	50.4	23.1	26.4	32.4	89.5	92.3	95.1	52.3	53.9	55.6
Finland	5.0	9.5	11.9	3.4	6.5	8.1	28.7	32.9	40.4	19.5	22.3	27.4	9.5	9.8	10.1	6.5	6.7	6.9
France	7.5	14.5	18.0	5.4	10.5	13.1	46.0	52.6	64.8	32.9	37.6	46.3	62.0	63.9	65.9	38.4	39.6	40.8
Germany	7.1	13.6	17.0	4.5	8.6	10.7	48.9	55.9	68.8	30.6	35.0	43.0	122.2	126.0	129.9	65.4	67.5	69.5
Ireland Rep.	11.2	21.6	26.9	8.8	16.9	21.1	19.5	22.3	27.5	15.3	17.5	21.5	60.2	62.1	64.0	47.2	48.7	50.1
Nether-lands	6.2	12.0	14.9	3.9	7.5	9.4	55.9	63.8	78.6	35.8	41.0	50.4	151.9	156.6	161.3	85.2	87.9	90.5
Sweden	3.9	7.6	9.5	2.5	4.9	6.1	27.4	31.3	38.5	17.5	20.0	24.6	19.5	20.1	20.7	12.5	12.9	13.3
Switzer-land	5.1	9.8	12.2	3.1	6.0	7.5	52.3	59.8	73.6	32.3	36.9	45.5	59.3	61.2	63.0	36.6	37.8	38.9
UK	7.7	14.9	18.6	4.5	8.6	10.7	46.6	53.2	65.5	26.9	30.8	37.9	53.4	55.0	56.7	30.9	31.8	32.8

Table 28

The influence of traffic volumes on accident risks and accident costs is not yet clear. Different studies indicate that accident risks decline with increasing traffic volumes. The following table gives an overview on marginal accident costs from different UNITE case studies (see Lindberg 2002 for details):

MARGINAL EXTERNAL ACCIDENT COSTS RESULTS OF SELECTED UNITE CASE STUDIES				
Vehicle category	**All roads**	**Motorways**	**Inter-urban Roads**	**Urban Roads**
Results for Switzerland, €/vkm				
Cars	0.012	0.003	0.016	0.042
Motorcycles	0.080	0.002	0.055	0.309
Coaches	0.132	0.009	0.208	0.774
Urban Public transport	0.025	-	0.039	0.047
LDV	0.014	0.003	0.021	0.053
HDV	0.018	0.003	0.027	0.107
Sweden HDV, €/vkm				
Sweden average >12t	0.0084	-	-	-
12t – 14.9t (2)	(-0.00081)	-	-	-
15t – 18.9 t (3)	0.0062	-	-	-
19t – 22.9 t (4)	0.0074	-	-	-
23t – 26.9t (5)	0.0081	-	-	-
27t – 30.9t (6)	0.016	-	-	-
Above 31 t (7)	0.032	-	-	-

Table 29 Source: Lindberg 2002, Sommer et al. 2002.

The results of the UNITE case studies are in the same order of magnitude but generally lower than the results of our calculations. Most important are the assumptions concerning the internalisation of the accident risk. The above presented UNITE results for Switzerland are based on the assumption that the causer of an accident normally bears only his consequences of the accident, but not (or just partly) the costs of the non-responsible victims. If the average accident risk is considered to be internalised (because the transport users are supposed to be aware of the average risk), the result – due to the under proportional increase in the number of accidents and the fact that payments of insurances and social security to traffic accident victims and their dependents respectively – are negative marginal costs in the range between € -0.004 and -0.031 per vkm, according to different road types.

4.2.2. NOISE COSTS

According to the methodology described in the previous study and in Chapter 2.4 the subsequent sections show the results of the estimated marginal noise costs for characteristic traffic situations for road and rail traffic. For reasons of simplification the marginal cost estimates are averaged across time of day and traffic densities. The magnitude of these influencing variables can be estimated (cp. INFRAS/ IWW study 2000) as follows:

› The differences in marginal costs between day and night time stem from different target levels. For a 10 dB(A) reduction in accepted noise emissions e.g. marginal noise costs might increase by a factor of 2.5.
› A doubling in vehicles per hour in road, rail or air transport lets marginal noise costs decrease by approximately 30%.
› The average marginal cost values estimated for road, rail and air transport are presented by the following table.

MARGINAL NOISE COSTS BY MODE AND AREA 2000

Means of transport	Euro / 1000 vkm		Euro / 1000 pkm	
	Inter-urban	Urban	Inter-urban	Urban
Road				
Passenger car	0.14	18.42	0.07	13.16
Motorcycle	0.28	36.84	0.25	32.89
Bus / coach	0.71	92.10	0.05	4.61
LDV	0.71	92.10	2.37	307.01
HDV	1.31	169.47	0.25	31.98
Rail				
High speed rail	28.54	229.18	0.09	0.73
Traditional rail	32.61	399.10	0.13	1.61
Freight	34.35	574.64	0.06	1.08
Aviation*				
Passenger	590.04	1'102.79	6.54	16.96
Freight	590.04	1'102.79	47.19	88.22
Waterborne				
Freight	0.00	0.00	0.00	0.00

Table 30 Marginal noise costs by mode and area 2000 (*The columns 'inter-urban' and 'urban' here denote short- and long distance flights).

The table allows the following conclusions:
› The marginal cost values per tonne kilometre in road haulage are very high compared to the marginal cost values in rail goods transport, which is due to the much bigger package size in rail compared to HDV. The same conclusion can be drawn for passenger transport, but the results heavily depend on train occupancy factors.
› Marginal noise costs of road transport in urban areas are roughly a factor 100 higher than the values obtained in rural areas. However, here the population densities, the structure of settlements and transport infrastructure and traffic densities play a decisive role for the level of national (or average) noise costs in particular cases.

- Due to these high differences of values, a direct comparison of marginal and average costs is difficult. However, the results indicate, that in road transport average costs are located between marginal costs in rural and in urban areas. Only in rail transport marginal costs are well below average costs (across all countries). However, this result strongly varies with train occupancy or loading factors.
- The noise emissions per passenger or tonne kilometre estimated for air transport exceed the values calculated for the land-based transport modes. However, as the estimation of airport noise emissions is based on average costs the present results need to be regarded with care.
- Waterborne goods transport is assumed not to cause noise pollution.

As noise costs are extremely sensitive to the affected region an in-depth analysis of local conditions is strongly recommended in order to make cost values reliable.

Road transport

The table below displays the social marginal noise costs caused by road transport vehicles (in combination with the scenarios used for the INFRAS/ IWW 2000 study). The values are presented in Euro per 1000 vehicle, passenger and tonne kilometres for cars, motorcycles, buses, LDVs and HDVs. Assumptions, which are necessary for the calculation of marginal costs, are taken from the previous study. The interpretation of the calculated results can also be done analogously to the previous study.

MARGINAL NOISE COSTS FOR ROAD TRAFFIC IN DIFFERENT TRAFFIC SITUATIONS SCENARIOS ALREADY USED FOR THE INFRAS/IWW 2000 STUDY												
Scenarios			**Marginal costs per vehicle kilometre**					**Marginal costs per pass. / tonne kilometre**				
			Euro / 1000 vkm					**Euro / 1000 pkm**			**Euro / 1000 tkm**	
Area	**Time**	**Traffic**	**Car**	**MC**	**Bus**	**LDV**	**HDV**	**Car**	**MC**	**Bus**	**LDV**	**HDV**
Rural	Day	Thin	0.14	0.28	0.69	0.69	1.27	0.07	0.25	0.05	2.30	0.24
		Dense	0.06	0.13	0.32	0.32	0.58	0.03	0.11	0.02	1.05	0.11
	Night	Thin	0.25	0.50	1.26	1.26	2.31	0.13	0.45	0.08	4.19	0.44
		Dense	0.12	0.23	0.58	0.58	1.06	0.06	0.21	0.04	1.92	0.20
Sub-urban	Day	Thin	1.19	2.39	5.97	5.97	10.99	0.63	2.13	0.40	19.91	2.07
		Dense	0.43	0.86	2.14	2.14	3.94	0.23	0.77	0.14	7.14	0.74
	Night	Thin	2.18	4.35	10.88	10.88	20.01	1.14	3.88	0.73	36.26	3.78
		Dense	0.78	1.56	3.90	3.90	7.18	0.41	1.39	0.26	13.01	1.35
Urban	Day	Thin	18.49	36.98	92.45	92.45	170.11	13.21	33.02	4.62	308.18	32.10
		Dense	7.63	15.25	38.13	38.13	70.16	5.45	13.62	1.91	127.11	13.24
	Night	Thin	33.68	67.35	168.38	168.38	309.82	24.05	60.14	8.42	561.26	58.46
		Dense	13.89	27.78	69.45	69.45	127.79	9.92	24.80	3.47	231.50	24.11

Table 31 Marginal noise costs for road traffic in different traffic situations

In general the comparison of marginal and average noise costs is difficult as they are computed on a very different basis. While for average costs the different national practices of estimating the number of inhabitants exposed to certain noise levels and sources diverges from country to country, the scenarios selected for estimating marginal costs might not reflect the distribution of traffic conditions in Europe adequately.

Rail transport

The marginal costs of rail passenger and goods transport in general show a similar picture to the systematic found in road traffic noise. Assumptions, which are necessary for the calculation of marginal costs, are taken from the previous study. The interpretation of the calculated results can be also done analogously to that report.

MARGINAL NOISE COSTS FOR RAIL TRAFFIC IN DIFFERENT TRAFFIC SITUATIONS
SCENARIOS ALREADY USED FOR THE INFRAS/IWW 2000 STUDY

Scenarios			**Marginal costs per train kilometre**			**Marginal costs per pass. / tonne kilometre**		
			Euro / 1000 vkm			**Euro / 1000 pkm**		**Euro / 1000 tkm**
Area	**Time**	**Traffic**	**HST**	**IRT**	**FT**	**HST**	**IRT**	**FT**
Rural	Day	Thin	25.2	28.8	30.3	0.08	0.12	0.06
		Dense	15.3	17.4	18.4	0.05	0.07	0.03
	Night	Thin	45.9	52.4	55.2	0.15	0.21	0.10
		Dense	27.8	31.8	33.5	0.09	0.13	0.06
Suburban	Day	Thin	174.0	198.9	209.5	0.56	0.80	0.40
		Dense	106.1	121.2	127.7	0.34	0.49	0.24
	Night	Thin	316.9	362.2	381.5	1.01	1.46	0.72
		Dense	193.1	220.7	232.5	0.62	0.89	0.44
Urban	Day	Thin	0.0	0.0	424.8	0.00	0.00	0.80
		Dense	0.0	274.8	322.5	0.00	1.11	0.61
	Night	Thin	569.6	821.2	963.8	1.82	3.31	1.82
		Dense	347.1	500.4	587.4	1.11	2.02	1.11

Table 32 Marginal noise costs for rail traffic in different traffic situations (HST = High-speed train, IRT = Inter-regional passenger train; FT = Freight train).

The comparison of marginal noise costs in rail passenger transport (per pkm) are slightly lower than those computed for rail freight traffic (expressed per tkm), but the values range in the same order of magnitude. The same comparison with average costs shows that noise costs of passenger transport are slightly higher than average noise costs of freight transport. This is explained by methodological problems separating the number of inhabitants disturbed by traffic noise to different times of day for estimating average costs.

Thus, the fact that rail freight traffic mainly takes place during the night and passenger train movements in first instance occur during daytime could not be adequately acknowledged by the cost allocation procedure. Accordingly, noise costs of rail freight transport are probably under-estimated while the average cost values in passenger transport are presumably too high. In contrast, the model-based calculation scheme for marginal costs was able to reflect these characteristics and thus the relative noise cost levels of freight and passenger services as expressed by the marginal cost values are more realistic than of the average cost values computed on the basis of the noise exposure database.

Aviation

Referring to the methodology concerning marginal costs the evaluation of aviation noise emissions is based on a more pragmatic approach (cp. INFRAS/ IWW 2000 study). While the rather dense networks of the land-based modes road and rail justify the presentation of characteristic example situations, which can be identified all over Europe, the comparably limited number of airports (as the noise emitters of aviation) requires a more country-based estimation of marginal noise costs.

The starting point of the estimation are the average costs per country in Euro per 1000 passenger or ton kilometre (see summary of European values in Table 21). According to the methodological assumptions made in section 2.4.4 a range of marginal costs between 30% and 60% of average costs per country can be derived from the calculations in road and rail transport. Out of this range of values the lower and upper limits of marginal cost estimates for aviation are determined. The range of marginal social noise cost estimates in aviation for Europe is shown in Table 33.

MARGINAL NOISE COSTS FOR AIR TRANSPORT FOR DIFFERENT TRAFFIC SITUATIONS						
Average cost estimate	**Average costs**		**Marginal costs low estimate**		**Marginal costs high estimate**	
	Passenger €/1000 pkm	Freight €/1000 tkm	Passenger €/1000 pkm	Freight €/1000 tkm	Passenger €/1000 pkm	Freight €/1000 tkm
Low (AT, SE)	0.24	1.0	0.1	0.3	0.2	0.6
High (IT, NL)	6.0	28.6	2.0	9.5	4.0	19
Total EUR 17			0.1	0.3	4.0	19

Table 33 Marginal noise costs for air transport for different traffic situations

Amongst other determinants, such as population density, terrain and weather conditions, the difference between marginal and average costs depends on the prevailing traffic level. While at low traffic densities the effect of an additional (marginal) vehicle is above that of the average fleet, e.g. marginal costs are higher than average costs, the degressive slope of the marginal cost function causes marginal costs to fall below average costs at high traffic volumes. Thus, the same type of aircraft will cause less marginal costs at highly frequented airports than at less frequented ones.

The upper bound of average noise costs is marked by the Netherlands, which is not surprising due to their high population density. Thus it can be assumed that airports are located close to settlements, which indicates that marginal social noise costs of less frequented airports in the Netherlands are well above the European average. On the other side, Austria shows the lowest level of average noise costs. Considering highly frequented airports, i.e. the capital airport of Vienna, this leads to the lower bound of the marginal cost estimates.

4.2.3. AIR POLLUTION COSTS

The following table presents the results for the most important vehicle categories, technologies and traffic situations. The results are based on average cost calculations using differentiated emission factors for PM10.

MARGINAL AIR POLLUTION COSTS FOR STANDARD TRAFFIC SITUATIONS €/1'000 VKM/PKM				
Vehicle type	**Technology**	**Emission factors** g/vkm	**Marginal Costs** €/1'000 vkm	**Marginal Costs** €/1'000 pkm/tkm
Passenger car urban	Gasoline	0.045	9.54	5.72
	Diesel	0.350	74.74	44.86
Passenger car inter-urban	Gasoline	0.045	9.54	5.80
	Diesel	0.141	30.12	18.32
Two-wheelers	Gasoline	0.017	3.59	3.21
Buses	Diesel	1.361	310.76	17.74
Coaches	Diesel	0.966	220.64	11.65
HDV	Diesel	1.084	227.29	33.50
LDV	Gasoline	0.059	11.36	15.14
	Diesel	0.394	75.62	100.82
Train Passenger	-	6.00	696.00	5.1
Train Freight	-	21.40	2'437.00	7.4
Air Passenger	-	-	24.0	0.2
Air Freight	-	-	-	1.8
Waterborne Transport		-	-	8.8

Table 34

4.2.4. CLIMATE CHANGE COSTS

Table 35 presents the results for the main clustering. The results are comparable with the average costs, but differ especially according to the differentiation used. Road transport causes higher marginal costs in urban areas than in interurban traffic.

MARGINAL CLIMATE CHANGE COSTS				
	Minimum shadow value: € 20 per t CO_2		**Maximum shadow value: € 140 per t CO_2**	
	€ per 1'000 vkm	€ per 1'000 pkm/tkm	€ per 1'000 vkm	€ per 1'000 pkm/tkm
Passenger Car urban (all techniques)	6.4	3.9	45.0	27.0
Passenger Car interurban (all techniques)	2.9	1.7	20.2	12.2
Urban Bus Diesel	23.6	1.4	165.0	9.5
Coaches Diesel	13.2	0.7	92.3	4.9
Two-wheelers	1.9	1.7	13.1	11.7
LDV (all techniques)	6.1	8.2	42.6	57.4
HDV Diesel	12.4	1.8	86.5	12.8
Train Passenger Diesel	116	1.0	814	7.1
Train Passenger Electric	108	0.8	754	5.4
High Speed Train	56	0.3	393	2.2
Train Freight Diesel	237	0.8	1'658	5.3
Train Freight Electric	119	0.4	832	2.7
Aviation Passenger	931	6.6	6'517	46.2
Aviation Freight	-	33.7	-	235.7
Waterborne Freight	402	0.6	2'812	4.3

Table 35

4.2.5. COSTS FOR NATURE AND LANDSCAPE

Marginal costs for nature and landscape have to be distinguished between short and long run. In the short run, infrastructure is given and an additional vehicle does not cause additional effects. In the long run however, new infrastructure will be necessary leading to additional effects. As mentioned in chapter 2, theses costs might amount to the same level as the average costs. The spatial differentiation shows a zero value for urban transport, since additional infrastructure is causing mainly scarcity problems and does not harm nature.

MARGINAL COSTS FOR NATURE AND LANDSCAPE			
	Short run marginal cost	Long run marginal cost	
		€ per 1'000 vkm	€ per 1'000 pkm/tkm
Passenger Car urban	0	0.0	0.0
Passenger Car interurban	0	4.0	2.1
Urban Bus	0	0.0	0.0
Coaches	0	25.7	1.3
Two-wheelers	0	2.1	1.9
LDV	0	36.2	10.9
HDV	0	11.5	0.8
Train Passenger	0	232	1.2
High Speed Train	0	232	0.7
Train Freight	0	75	0.1
Aviation Passenger	0	79	1.1
Aviation Freight	0	83	6.5
Waterborne Freight	0	922	0.8

Table 36 Marginal costs for nature and landscape for different traffic situations, expressed in costs per vehicle kilometres and per passenger resp. tonne kilometres.

4.2.6. ADDITIONAL COSTS IN URBAN AREAS

The following tables present marginal costs for separation effects and space availability. Marginal separation costs are rather high, since they refer to a specific situation. It is important to note that these costs only occur for specific traffic situations (for average vehicle frequencies of 400 to 800 vehicles). Lower speed (due to congestion) will decrease marginal costs significantly. Although there are positive average costs for the railways in urban areas, marginal costs are zero, since separation is not dependent from the train frequency. This is true for highways as well.

MARGINAL SEPARATION COSTS FOR URBAN TRANSPORT MEANS URBAN MAIN ROADS		
	€/1'000 vkm	**€/1'000 pkm resp. tkm**
Pass. Car	16.0	9.6
Bus	39.9	2.2
Motorcycle	8.0	7.1
LDV	24.0	32.3
HDV	47.9	7.1
Inter-city Train Passenger	0	0

Table 37

Marginal space availability costs are in the short run zero, since it is a fixed cost component. In the long run however, they are positive, since additional infrastructure seeks as well for increased space availability for bicycle lanes. They are similar to average costs. In comparison to average costs estimated in the results chapter however, they are significantly higher, since they only refer to the mileage driven on urban main roads.

MARGINAL SPACE AVAILABILITY COSTS FOR URBAN TRANSPORT MEANS
URBAN MAIN ROADS

	Short run marginal costs	Long run marginal costs	
		€/1'000 vkm	€/1'000 pkm resp. tkm
Pass. Car	0	1.77	1.07
Bus	0	1.93	0.11
Motorcycle	0	0.77	0.69
LDV	0	2.25	3.04
HDV	0	6.01	0.89
Inter-city Train Passenger	0	1.77	1.07

Table 38

4.2.7. UP- AND DOWNSTREAM PROCESSES

Up- and downstream processes are in general in line with the mileage driven, but with different time horizons. In the short run only precombustion (production and transport of energy for transport purposes) is directly depending on vehicle kilometres. The following table presents these short run marginal costs, which are slightly below 50% of long run marginal (eq. average) costs. Within rail transport, they are lower for diesel than for electricity driven rolling stock, since the main components of diesel trains are already included in marginal air pollution and climate change costs. For electricity trains, the main short run marginal cost component is the nuclear power risk. Since it is a marginal cost component, the value is equal for different countries, since an additional train is consuming electricity based on an international marginal mix (based on the average UCPTE mix) within a liberalised energy market.

MARGINAL COSTS FOR UP- AND DOWNSTREAM PROCESSES EURO PER VKM AND PKM, TKM				
	Short run marginal costs		**Long run marginal costs**	
	per vkm	**per pkm, tkm**	**per vkm**	**per pkm, tkm**
Car	3.3	2.0	6.7	4.1
Bus	46.6	2.6	108.3	6.0
MC	1.5	1.3	3.0	2.7
LDV	9.7	13.0	17.4	23.4
HDV	24.1	3.6	50.5	7.4
Passenger Train Electric	151	1.10	737	5.36
Passenger Train Diesel	128	0.93	1'143	8.30
Freight Train Electric	99	0.30	107	0.33
Freight Train Diesel	64	0.20	543	1.66
Air passenger transport	115	0.81	128	0.91
Waterborne Transport	860	0.75	2'007	1.76

Table 39 Marginal costs for up- and downstream processes for different traffic situations.

4.2.8. CONGESTION COSTS

The calculation of marginal costs presumes the specification of local traffic conditions and thus the development of the European transport environment or changing network specifications of the model for computing total congestion costs do not impact marginal cost results. The only sensitive variables for the computation of marginal costs per vehicle kilometre are the value of time per passenger and goods, vehicle occupancy rates or loading factors and the prevailing traffic mix. The loading factors have been taken from the TREND database and the changes in the value of time and traffic mix parameters have been set in accordance to the total cost accounting scheme.

Table 40 presents an overview of the marginal costs for dense, but not totally congested traffic conditions. The following outputs of the calculation scheme are shown:

- Marginal social costs (MSC) under current conditions.
- Charge: This value represents the marginal social costs after a sophisticated congestion pricing system had been implemented, which is equal to its toll level.
- Av. DWL: The average deadweight loss gives an indication of the welfare gain per unit priced (vehicles, passengers or tons of goods) achieved under a congestion pricing regime.

I.e. the second value represents the decisive economic measures of congestion per traffic unit. These values range around 1 € per vehicle kilometre for passenger cars, while the related average deadweight loss is only a friction of that - and particular in the more congested urban networks.

SELECTED MARGINAL COST VALUES FOR ROAD CONGESTION
ACTUAL EXTERNAL COSTS, OPTIMAL CHARGES AND AVERAGE DEADWEIGHT LOSS

Cost category	MSEC	Charge	Av. DWL	MSEC	Charge	Av. DWL
	Euro / 1000 vkm			Euro / 1000 pkm, tkm		
Passenger car						
- Inter-urban	1977.4	1004.2	77.6	1284.0	652.1	50.4
- urban	2708.0	1594.9	60.1	1592.9	938.2	35.3
Motorcycle						
- Inter-urban	988.7	502.1	38.8	898.8	456.5	35.3
- urban	1354.0	797.5	30.0	1230.9	725.0	27.3
Bus						
- Inter-urban	3954.8	2008.5	155.1	131.8	66.9	5.2
- urban	5415.9	3189.8	120.2	270.8	159.5	6.0
LDV						
- Inter-urban	2966.1	1506.4	116.4	4237.3	2152.0	166.2
- urban	4062.0	2392.4	90.1	5802.8	3417.6	128.8
HDV						
- Inter-urban	6921.0	3514.9	271.5	1017.8	516.9	39.9
- urban	9477.9	5582.2	210.3	1393.8	820.9	30.9

Table 40 Summary of marginal congestion costs.

Table 41 shows the detailed results for marginal congestion costs under various traffic conditions. Here it gets obvious that simple average values are not very helpful for setting concrete pricing schemes. The values also show that the ratio between the average deadweight loss per vehicle kilometre and the charges to be raised to reach this welfare gain improves when traffic gets denser.

Although the UNITE results have lead to a slightly increasing value of time, in particular for light goods vehicles, the results presented in this update study are in the same order of magnitude than the marginal costs reported in the 2000 study.

SELECTED MARGINAL COST VALUES FOR ROAD CONGESTION
ACTUAL EXTERNAL COSTS, OPTIMAL CHARGES AND AVERAGE DEADWEIGHT LOSS

MSEC, Charges and av. DWL	MSEC	Charge	Av. DWL	MSEC	Charge	Av. DWL
	Euro / 1000 vkm			Euro / 1000 pkm, tkm		
Passenger car						
- Motorway						
- Relaxed	10.7	10.7	0.0	6.9	6.9	0.0
- Dense	1.977.4	1.004.2	77.6	1.284.0	652.1	50.4
- Congested	2.032.0	1.477.8	194.6	1.319.5	959.6	126.4
- Rural						
- Relaxed	37.3	37.3	0.0	24.2	24.2	0.0
- Dense	1.253.6	802.9	2.1	814.0	521.4	1.4
- Congested	1.950.9	1.687.3	28.3	1.266.8	1.095.6	18.4
- Urban						
- Relaxed	25.9	25.9	0.0	15.2	15.2	0.0
- Dense	2.708.0	1.594.9	60.1	1.592.9	938.2	35.3
- Congested	3.096.1	2.205.3	178.5	1.821.2	1.297.2	105.0
Motorcycle						
- Motorway						
- Relaxed	5.4	5.4	0.0	4.9	4.9	0.0
- Dense	988.7	502.1	38.8	898.8	456.5	35.3
- Congested	1.016.0	738.9	97.3	923.7	671.7	88.4
- Rural						
- Relaxed	18.7	18.7	0.0	17.0	17.0	0.0
- Dense	626.8	401.5	1.0	569.8	365.0	0.9
- Congested	975.4	843.6	14.1	886.8	766.9	12.9
- Urban						
- Relaxed	12.9	12.9	0.0	11.8	11.8	0.0
- Dense	1.354.0	797.5	30.0	1.230.9	725.0	27.3
- Congested	1.548.1	1.102.7	89.2	1.407.3	1.002.4	81.1
Bus / coach						
- Motorway						
- Relaxed	21.4	21.4	0.0	0.7	0.7	0.0
- Dense	3.954.8	2.008.5	155.1	131.8	66.9	5.2
- Congested	4.064.1	2.955.7	389.2	135.5	98.5	13.0
- Rural						
- Relaxed	74.6	74.6	0.0	2.5	2.5	0.0
- Dense	2.507.2	1.605.8	4.2	83.6	53.5	0.1
- Congested	3.901.7	3.374.6	56.6	130.1	112.5	1.9
- Urban						
- Relaxed	51.7	51.7	0.0	2.6	2.6	0.0
- Dense	5.415.9	3.189.8	120.2	270.8	159.5	6.0
- Congested	6.192.2	4.410.6	356.9	309.6	220.5	17.8
LDV						
- Motorway						
- Relaxed	16.1	16.1	0.0	22.9	22.9	0.0
- Dense	2.966.1	1.506.4	116.4	4.237.3	2.152.0	166.2
- Congested	3.048.1	2.216.8	291.9	4.354.4	3.166.8	417.0
- Rural						
- Relaxed	56.0	56.0	0.0	80.0	80.0	0.0
- Dense	1.880.4	1.204.4	3.1	2.686.3	1.720.5	4.5
- Congested	2.926.3	2.530.9	42.4	4.180.4	3.615.6	60.6
- Urban						
- Relaxed	38.8	38.8	0.0	55.4	55.4	0.0
- Dense	4.062.0	2.392.4	90.1	5.802.8	3.417.6	128.8
- Congested	4.644.2	3.308.0	267.7	6.634.5	4.725.7	382.4
HDV						
- Motorway						
- Relaxed	37.5	37.5	0.0	5.5	5.5	0.0
- Dense	6.921.0	3.514.9	271.5	1.017.8	516.9	39.9
- Congested	7.112.2	5.172.4	681.1	1.045.9	760.6	100.2
- Rural						
- Relaxed	130.6	130.6	0.0	19.2	19.2	0.0
- Dense	4.387.7	2.810.2	7.3	645.2	413.3	1.1
- Congested	6.828.0	5.905.5	99.0	1.004.1	868.5	14.6
- Urban						
- Relaxed	90.5	90.5	0.0	13.3	13.3	0.0
- Dense	9.477.9	5.582.2	210.3	1.393.8	820.9	30.9
- Congested	10.836.4	7.718.6	624.6	1.593.6	1.135.1	91.9

Table 41 Detailed results for marginal congestion costs.

5. INTERPRETATION OF RESULTS AND POLICY CONCLUSIONS

5.1. COMPARISON WITH 1995 RESULTS

Total costs increase in the period 1995–2000 by 12.1% (1995 values adjusted to 2000 prices). The main reason for this development are increasing traffic volumes which lead to higher green house gas emissions and thus to increasing climate change risks (especially in road passenger transport and air passenger transport). Another cost category which shows increasing costs are air pollution costs especially for road freight transport. Although PM10 exhaust emissions decrease significantly due to improved engine technologies and particle filters, non exhaust emissions increase more or less in line with traffic volumes.

COMPARISON: TOTAL EXTERNAL COSTS 1995 AND 2000 (EXCLUDING CONGESTION)

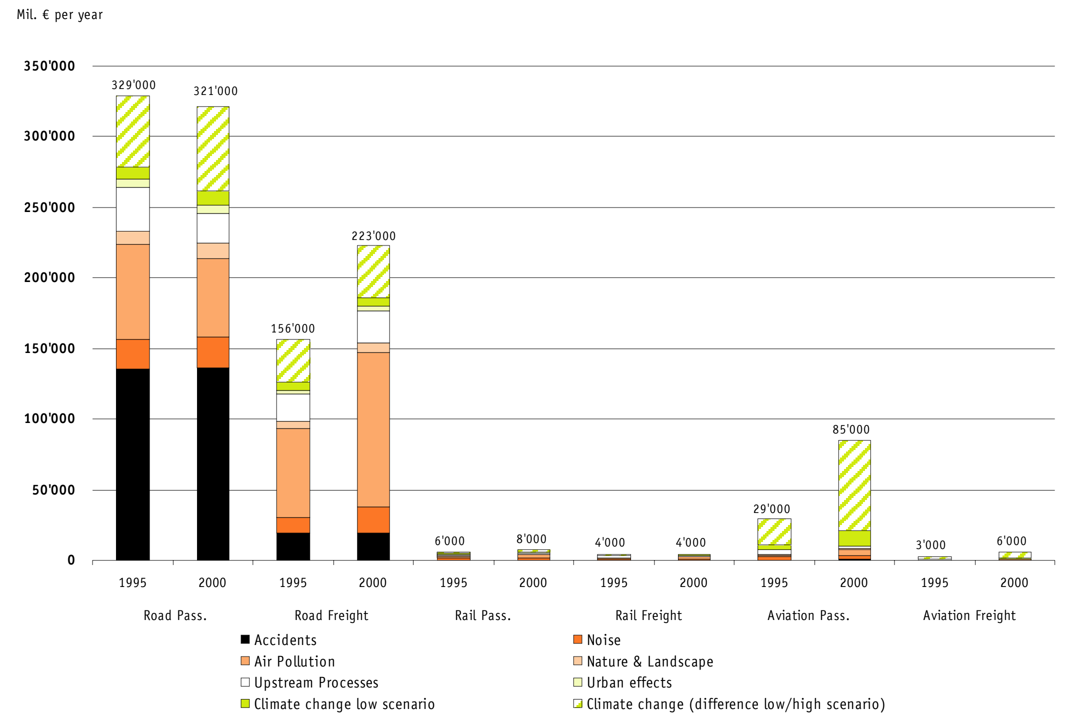

Figure 22 Comparison with the total external costs between the years 1995 and 2000 by transport means and cost category (1995 values at 1995 prices, 2000 values at 2000 prices).

COMPARISON: AVERAGE EXTERNAL COSTS 1995 AND 2000 PASSENGER TRANSPORT

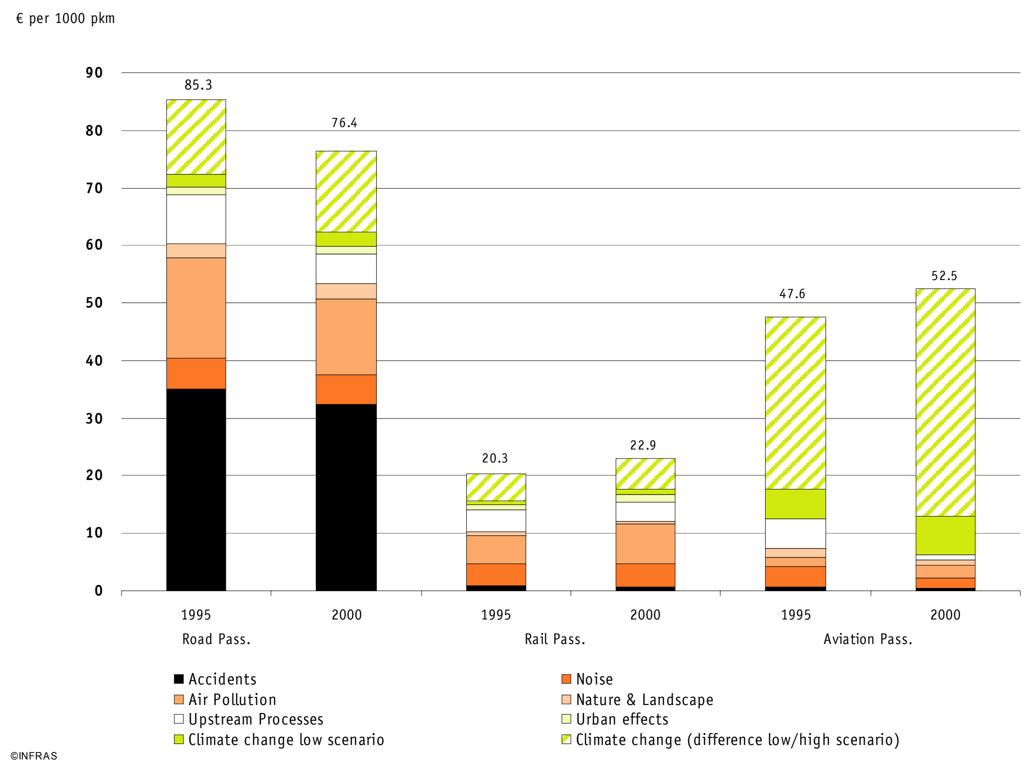

Figure 23

In passenger transport average costs remain more or less stable. The following conclusions can be drawn:

› In road passenger transport a nominal decrease of average external costs of around 8% could be observed. This is mainly due to a decline of accident costs (improved road safety in almost all countries), lower air pollution costs and lower costs of up and down-stream processes. Lower air pollution costs in road passenger transport are the result of an improved emission data base which leads to a new cost allocation of total air pollution costs to the different means of transport.

› A nominal increase of around 13% of average costs in rail passenger transport is mainly a result of new non exhaust emission factors for rail transport which lead to higher air pollution costs attributed to rail transport[19]. Another reason for the increase is a better database on rail noise exposure.

› The increase in average air passenger transport (+10%) is a result of an improved database on aviation emissions especially regarding CO_2 emissions. At the same time new data on up- and downstream processes lead to a decreasing average costs for up- and downstream processes.

COMPARISON: AVERAGE EXTERNAL COSTS 1995 AND 2000 FREIGHT TRANSPORT

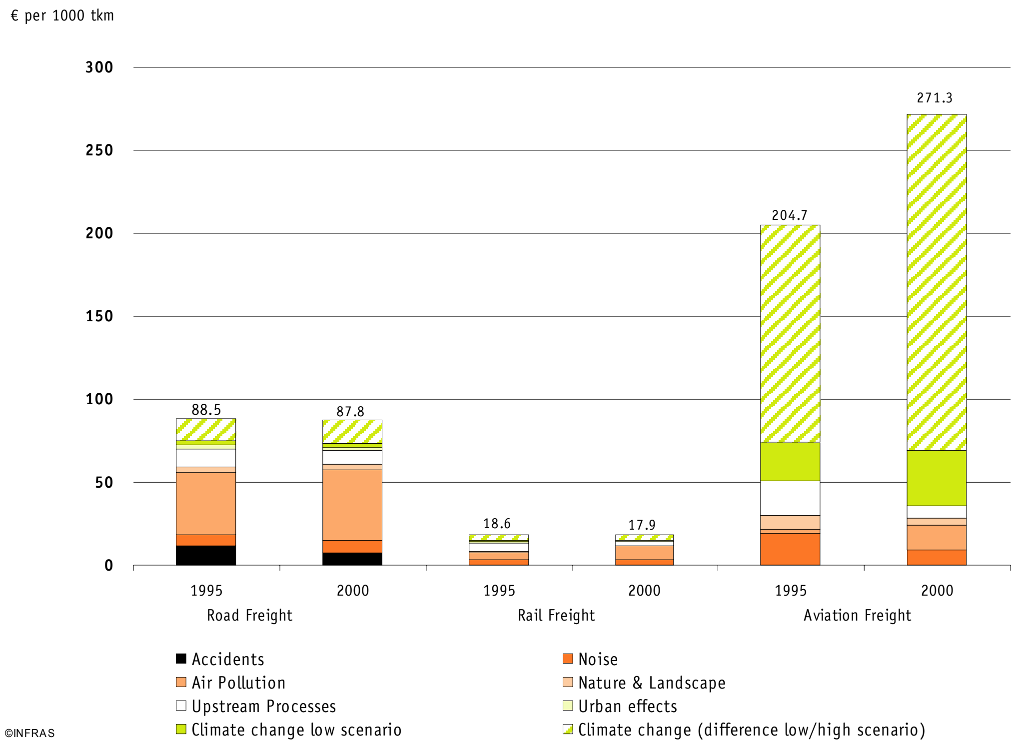

Figure 24

In freight transport average external costs show only small changes. The following conclusions can be made:

19 The study on non-exhaust emissions for Switzerland (BUWAL 2003) is still going on with the general aim to verify the so far published data.

- Average costs in road freight transport decrease by ca. 1%. There is a slight decrease of average accident costs (-35%) while air pollution (+14%) and noise costs (+11%) increased.
- In rail freight transport average costs decrease by 4%. Although air pollution costs increase significantly (the reason for this development is explained above) a noticeable decrease of noise and climate change costs as well as declining costs for up- and downstream processes can be observed.
- Air freight transport shows significant changes (+33%) which are mainly the result of an improved database on aviation. However it has to be stated that only mixed air transport (i.e. passenger and freight transport) is considered because there was no data available on cargo-only air services. The allocation of emissions and costs to passenger and freight transport was made using a conversion factor of 190 kg for each passenger.

5.2. POLICY DISCUSSION

5.2.1. INTERNALISATION STRATEGIES

Discussion of Social Marginal Cost Pricing

Strategies for the internalisation of external costs of transport have been widely discussed in the last decade, on policy level and on scientific level at the same time. The focus of this discussion is strongly related to the discussion of fair and efficient pricing of transport in Europe. This discussion has been launched on EU-level with the Green Paper on fair and efficient pricing (1996) and the following White Paper on fair infrastructure use (1998). Especially the latter has related the internalisation strategies to the principle of social marginal cost pricing, based on economic welfare theory. Several studies (e.g. Proost et al. 1999, UNITE 2003) have shown that the integral implementation of such a principle would maximise economic welfare and lead to significantly higher level of efficiency in the overall transport system. The most important impacts of the implementation of social marginal cost pricing can be summarised as follows:

- Efficient and optimal prices are slightly different to the level of marginal cost estimated in this report. They would be a little bit lower since prices reflect also demand reactions. This is most important for road pricing in urban areas,
- Transport prices (especially for road transport) would increase in the urban areas, especially for road transport, compared to today's situation. This is due to the fact that external congestion costs are rather high compared to normal service conditions. On the other hand, road costs for peripheral areas without congestion would decrease.

- On average, the price level would slightly increase compared to today's situation. This means: Generated revenues by a pricing system according to social marginal costs would increase for road transport.

The recent policy discussion has shown that a stringent implementation of the theoretical approach is not possible and appropriate, due to theoretical, practical and financial reasons (see also INFRAS/UIC 1998):

- Since congestion costs are the most important category, the approach is very sensitive in regard to the level of these costs. The importance of external congestion costs applies for a highly differentiated road pricing system which is too complicated for users and too costly. Besides there are social arguments to consider like unwanted distribution effects and the guarantee of individual data security.
- The approach is not feasible for transparent financing schemes and institutional approaches, since full cost recovery is not possible.
- The approach is too narrow, especially for problems like noise and accident costs. Marginal noise and accident costs are much lower than the related average cost figures, if the pricing principle is focussing on additional costs per vehicle kilometre.

This leads to the conclusion that a wider concept is needed which differentiates between the recovery of infrastructure costs considering scarcities and external costs (accidents, environment) which can be internalised by a set of instruments.

A wider concept: Internalisation as part of a sustainability concept

Besides efficiency, other aims should be considered, related to the criteria of sustainable transport, such as

- Effectiveness: Significant reduction of environmental nuisances (such as air pollution, noise, greenhouse gases) and increase of safety,
- Long term focus, incl. the possibility to finance future transport infrastructure,
- Practicability and transparency for the users,
- Consideration of sensitive areas.

Such a wider concept has three pillars, which can be characterised as follows:

1. An improved pricing system, which considers the different level of external costs between modes, as well in the price level and in the pricing structure.
2. Additional (non pricing) instruments which support the reduction of the level of environmental and accident costs.

3. An institutional framework which allows sustainable decisions on infrastructure investment and financing.

5.2.2. INSTRUMENTS

Overview of most important instruments

According to the pillars mentioned above, we can differentiate pricing (in a larger context also other economic) and non economic instruments. The following Table 42 gives an overview of the most important instruments.

The table indicates that the internalisation of external costs is only successful, if a mix of instruments is used in different transport sectors is applied. The pricing instruments usually show a rather high level of cost-effectiveness (e.ge. efficiency), but are not always very effective in increasing safety or reducing environmental damages. Only in combination with other measures, such as technical measures and speed limits, an overall effectiveness and efficiency can be secured.

Steering and financing function of pricing instruments

The pricing instruments lead to steering and financing effects, for additional infrastructure measures (like for example safety measures or capacity increase), for the financing of organisational/institutional measures etc. This raises the question on the most efficient use of revenues of pricing measures. The following economic rules should be considered:

› Simple earmarkinging and the generation of specific transport funds are not efficient, but usually very effective. In order to raise efficiency and allocate funds properly, transparent economic rules (i.e. the use of socio economic cost benefit analysis) should be applied.
› Crossmodal or general transport infrastructure funds (i.e. the financing of rail infrastructure by using revenues from road pricing) are supposed to be useful and fair, since the use of financing rules for road and rail can be harmonised. Today's situation might enfavour road transport infrastructure since their financing means are earmarked. Crossmodal funds are especially useful to finance investments for areas or corridors, where the intermodal relation is rather strong (i.e. urban areas, sensitive regions, transalpine corridors, as it is applied in the Swiss approach).

OVERVIEW OF INTERNALISATION INSTRUMENTS			
	Type of instrument	**Effectiveness**	**Cost-Effective-ness-ratio (ranking)**
Congestion			
Peak load pricing	Economic	High	1
Infrastructure operation management, telematics	Technical	High	2
Accidents			
Education	Organisation/Institutional	Medium	1
Change of insurance/ liability(Bonus-Malus systems)	Economic	High	2
Limitation of alcohol limits	Command and Control	High	3
Speed limits	Command and Control	Very High	4
Courses for driving styles	Organisation/Institutional	High	5
Local measures	Infrastructure	Local High	6
Noise			
New brake systems rail	Technical	High	1
Motor caps for HDV	Technical	Low	2
Speed limits	Command and Control	Medium	3
Special tyres for road	Technical	Low	4
Noise walls/windows	Infrastructure	High	5
Air pollution			
Alternative motors for busses	Technical	Low	1
EURO IV+ norms	Command and Control	High	2
Km-tax (emission dependent) Fuel tax	Economic	High	3
Urban parking policy	Economic/Infrastructure	Medium	4
Urban Road Pricing	Economic	Medium	5
Urban traffic bans	Command and Control	High	6
Speed limits	Command and Control	Medium	7
Climate Change			
Driving courses	Organisation/Institutional	Medium	1
Kyoto Mechanisms (Emission trading, clean development mechanisms)	Economic	High	2
Fuel tax Kerosene tax	Economic	High	3
Renewable energies for electricity production (rail)	Technical	High	4
Alternative fuels (Bus/HDV)	Technical	High	5
Feebates Road	Economic	Low	6
Fuel standards/ alternative Fuels	Command and Control	Medium	7
Speed limits	Command and Control	Medium	8

Table 42 Overview of the most effective measures by type of externality (Source: Synthesis of different studies) Ranking: 1= Measures with best cost-effectiveness-ratio, based on INFRAS/UIC 1998 and own estimates.

5.2.3. FEEDBACK TO EU-POLICY AND MS-APPROACHES

EU-Policy

The ongoing debate on EU level can be characterised as follows:

› Road freight transport: The proposition of the Commission for a new directive to replace the Eurovignette Directive 1999/62 seeks for a variabilisation and differentiation of existing road taxes for HDV and applies a pricing principle which is based on full cost recovery of infrastructure costs and external accident costs. The tax can be differentiated according to environmental criteria (esp. EURO norms) and according to scarcity criteria (regional differentiation in order to consider congestion costs). In addition a surcharge to these costs is allowed in sensitive areas. The revenues should be used to recover infrastructure and accident costs. In sensitive areas, a crossmodal financing of infrastructure would be possible. Fixed charges (flat taxes, vehicle and purchase taxes) should be reduced.
  This proposal is considering at least parts of external costs and does not simply follow the social marginal cost approach. It however neglects environmental charges and does not aim at internalising those externalities directly. Furthermore the intermodal approach is rather weak.
› Road passenger transport: The harmonisation of national mineral oil taxes and vehicle taxes is a difficult approach at EU-level. At the same time new attempts for road pricing for passenger cars are going to be discussed, mainly at national level.
› Rail transport: The EU Rail Packages are proposing track pricing systems which at least cover variable cost of maintenance and operation. It is allowed to increase those prices according to the ability to pay of the users in order to cover larger parts of infrastructure costs. This approach is in general in line with efficient pricing schemes (like two part pricing). There are some incentives to differentiate track prices according to environmental criteria (noise characteristics). Capacity oriented prices however are not yet proposed.
› Aviation: The attempts to harmonise landing and emission charges for airports are ongoing. In addition there are proposals for new regimes for en-route charges, considering capacity constraints and environmental criteria.
› Climate policy: There a no attempts visible for a general CO2 charge on a European scale. Moreover there are attempts to push Kyoto mechanisms such as emission trading systems and CDM (clean development mechanisms), which lead to financing systems in the trans-

port sector: Small transport fees can be used to buy CO2-emission certificates in other sectors and countries.

Successful approaches at state level

In the last years, some successful internalisation strategies have been implemented at national level, for example

› the London congestion charge, which charges all motorised road transport vehicles in the centre area. Transport volumes have declined by more than 15%. The revenues are used to increase the supply of public transport, a widely accepted approach.
› the Swiss HDV charge, which is the first real internalisation charge based on estimates on external accident and environmental costs. The charge has reduced road HDV transport volumes by more than 3% and has shippers and freight forwarders motivated to use transport alternatives by rail. The revenues of the Swiss HDV tax are used to finance rail infrastructure (crossmodal funding).
› the German and Austrian approaches to introduce a new and km-dependent HDV charge for highways. The German charge is only related to infrastructure costs; there is a differentiation according to emission criteria and revenues are use to crossfinance also rail investments. In spite the technical problems for the time being, the technology (in contrast to Switzerland and Austria) has a high future potential.

Interpretation

Pricing measures have gained importance in the last years, especially in the freight sector. The new HDV charges are promising approaches to internalise external costs in the road freight sector. Based on latest experience, one has to state that the most important short term effect is the increase of HDV efficiency. Only in the longer run, modal shift effects can be expected, since reactions of shippers to change transport modes will take time and depend also on quality criteria. The development has shown that the strategy of variabilisation of fixed charges and the differentiation according to environmental criteria has become a common and widely accepted approach. Of great importance is the development of common pricing techniques and enforcement systems, in order to guarantee transnational interoperability.

As regards the situation of railways and the difference of external costs between rail, road and air transport, the development is heading in the right direction, but is not yet sufficient:

- There is no thorough consideration of environmental costs like air pollution and climate change in the level of prices. It is not sufficient to differentiate existing tax levels according to EURO criteria. The external costs should also be reflected in the level of prices.
- The approaches are mostly related to road freight transport. Passenger transport has been tackled so far only at the urban level in a few European cities.
- There is no climate policy visible which aims at accepting the high long term risks of climate change related to transport emissions and enfavours energy efficient rail transport.

5.2.4. PROPOSAL FOR AN INTERNALISATION STRATEGY AT EUROPEAN LEVEL

In order to internalise external costs properly, imbedded in a wider concept of sustainable transport, the following action lines are most important:

- A Km-dependent HDV tax in overall Europe which considers not only accident costs, but also environmental costs like air pollution, climate change and noise. Possible tax levels are according to average or marginal costs shown in this report. It is appropriate to apply such schemes not only for motorways.
- The introduction of road pricing schemes for passenger cars, primarily in urban areas, to consider capacity problems. An additional differentiation according to environmental criteria (e.g. air pollution) is appropriate.
- A fuel price scenario in Europe for all means of transport in order to meet the aims of a long term climate strategy; the rates of the respective CO2-tax should be in line with the proposed shadow prices (at minimum 20 Euro per tonne of CO2 related to the Kyoto targets). Most important is the inclusion of international air transport, in order to reduce tax distortions between transport modes.
- Additional measures in road transport in order to increase effectiveness, such as hi-tech-road management and intermodal information systems, such as improved liability systems and environmentally friendly and safe driving styles, supported by traffic calming measures (incl. speed limits).
- The application of rail track pricing systems considering external costs according to EU Directive 2001/14.

› More emphasis of the railways to speed up technical progress in improving environmental performance, such as wagon break improvements (see UIC Noise Action Plan) and energy efficiency (see UIC Diesel Action Plan, use of sustainable energy sources).

These most important internalisation instruments should be underlined with a comprehensive multimodal strategy with the following core elements:

› Multimodal financial funds, financed (at least partly) by externality charges from the road sector. These funds secure the necessary financial means for the modernisation of the railways. In order to allocate these financial means properly, the socio-economic return of the investments should be a major criteria and transparent budgetary rules of the fund administration are necessary.
› A priority to internalise external accident and environmental costs in these sectors (road and air transport) first, which cause high levels of externalities, in order to finance the proposed multimodal fund.

ANNEX 1: GENERAL INPUT DATA

OVERVIEW ON DATA AVAILABILITY

The following table presents the data used and the differences to the previous report.

OVERVIEW ON DATA SOURCES			
	Sources	**Based on**	**Remarks / Comparability (INFRAS/IWW 2000)**
Transport Volumes			
Road	› TRENDS1 database › BUWAL 2000	› Model calculations › Model calculations	Similar but improved data basis
Rail	› TRENDS1 database and UIC › BFS 2000 and SYN 2002	› Model calculations › National statistics	› Calibrated TRENDS data with UIC data Similar but improved data basis
Aviation	› TRENDS1 database › ICAO	› Model calculations › Airport statistics	› Model calculation see INFRAS/IWW 2000
Inland waterways	› TRENDS1 database	› Model calculations	Similar but improved data basis
Emissions			
Road	› TRENDS1 database › BUWAL 2000	› Model calculations › Model calculations	Similar but updated data basis
Rail	› UIC / TRENDS1 database › BUWAL 1996 › Swiss electricity production mix	› Model calculations › Model calculations › Model calculations	Similar but updated data basis › Swiss diesel trains (freight) › Swiss elect. trains
Aviation	› TRENDS1 database	› Model calculations	Similar but improved data basis
Inland waterways	› TRENDS1 database	› Model calculations	
Infrastructure			
Road	EUROSTAT	› National statistics	updated database
Rail	› UIC › BFS	› National statistics › National statistics	Similar but updated data basis
Aviation	INFRAS/IWW 2000	› Counted airports	same data as in INFRAS/IWW 2000
Inland waterways	EUROSTAT	› National statistics	Similar but updated data basis

OVERVIEW ON DATA SOURCES			
	Sources	**Based on**	**Remarks / Comparability (INFRAS/IWW 2000)**
Accidents			
Road	IRTAD Database	› National statistics	same data base as in INFRAS/IWW 2000, data on injuries fragmentary
Rail	UIC statistics	› National statistics	Similar but updated data basis
Aviation	EU Transport in Figures	› Airclaims, Aviation Safety Network (2000/2001data)	Similar but updated data basis
Inland waterways	not relevant	-	-

Table 43

DATA AVAILABILITY FOR NON EU COUNTRIES

Switzerland

Unfortunately there are neither traffic volume nor emissions data for Switzerland in the TRENDS1 database found. Other sources could fill up these gaps.

› Road transport volumes and emissions were found in the statistics of Swiss government (BUWAL, 2000).
› Detailed data on Swiss railway is hard to find. The UIC statistics gives us only aggregated numbers for passenger and freight train km. The newest complete data set separated after the traction types for train km is available for the year 1995. A total number for passenger km is found on the Bundesamt für Statistik (BFS) data pool, but only for the year 1997. Tonnes km for freight trains is available again in the UIC statistic for the year 2000, but only for the railway company SBB. Total emissions for diesel freight trains we found in BUWAL 1996. Emissions for electric trains are calculated with electricity consumption data and emission factors for the Swiss electricity production mix (INFRAS/IWW 2000).
› Data for Aviation: ICAO data.

Norway

Unfortunately there are neither traffic volume nor emissions data for Norway in the TRENDS1 database.

› We calculate transport volumes for Norway (pkm, tkm and vkm) by apply the Swedish growth factor on the Norwegian data from 1995 (INFRAS/IWW 2000). Some data are also

available on the Statistical Yearbook Norway 2002 on the internet. We used this data to check our calculations; except for the heavy duty vehicles we use this numbers.
› Road emissions were estimated by using Norwegian transport volumes (from the Statistical Yearbook Norway 2002) and Swedish vehicle km and emissions (from TRENDS1).

SOCIO-ECONOMIC DATA

Socio-economic data framework is taken from the EUROSTAT yearbook 2002 (EUROSTAT 2002).

Country	Shortcut	GDP	Population total	GDP per Capita	GDP per Capita PPS	Country Adjustment Factor	Area
Unit		Billion Euro	No.	Euro per Capita		EUR 17 = 100	km^2
Base year		2000	2000	2000	2000	2000	2000
AUSTRIA	AT	204.84	8'103'000	25'280	24'570	108.0	83'859
BELGIUM	BE	248.34	10'239'000	24'254	25'130	110.5	30'518
DENMARK	DK	176.49	5'330'000	33'113	27'140	119.3	43'094
FINLAND	FI	131.67	5'171'000	25'463	23'200	102.0	304'530
FRANCE	FR	1'404.78	59'226'000	23'719	22'250	97.8	543'965
GERMANY	DE	2'025.53	82'164'000	24'652	23'540	103.5	357'020
GREECE	GR	122.99	10'543'000	11'665	15'460	68.0	131'626
IRELAND	IE	103.47	3'777'000	27'395	26'800	117.8	70'273
ITALY	IT	1'165.68	57'680'000	20'209	22'890	100.6	301'316
LUXEMBOURG	LU	20.93	436'000	48'013	43'750	192.4	2'586
NETHERLANDS	NL	401.09	15'864'000	25'283	26'310	115.7	33'882
NORWAY	NO	175.51	4'479'000	39'184	31'200	137.2	307'860
PORTUGAL	PT	115.26	9'998'000	11'528	16'770	73.7	91'906
SPAIN	ES	608.79	39'442'000	15'435	18'110	79.6	504'790
SWEDEN	SE	246.62	8'861'000	27'832	22'960	101.0	410'934
SWITZERLAND	CH	259.58	7'164'000	36'234	28'300	124.4	39'769
UNITED KINGDOM	UK	1'547.90	59'623'000	25'962	23'560	103.6	243'820
Total		**8'959.46**	**388'100'000**	**23'085**	**22'743**	**100.0**	**3'501'749**

Table 44 Socio economic data of EU17 countries.

Gross domestic product (GDP) is the result of all production activity at market prices. It is the final result of the production activity of resident producer units. It can be defined in three ways.
› GDP is the sum of gross value added of the various institutional sectors or the various industries, plus taxes and less subsidies on products (which are not allocated to sectors and industries). It is also the balancing item in the total economy production account (production approach).

- GDP is the sum of final uses of goods and services by resident institutional units (actual final consumption and gross capital formation), plus exports and minus imports of goods and services (expenditure approach).
- GDP is the sum of uses in the total economy generation of income account (compensation of employees, taxes on production and imports less subsidies, gross operating surplus and mixed income of the total economy) (income approach) (ESA 95, 8.89).

In these tables, GDP corresponds to the economy's output of goods and services less intermediate consumption, plus VAT on products and net taxes (i.e. taxes less subsidies) linked to imports. Valuation at constant prices means valuing the flows and stocks in an accounting period at the prices of the reference period (ESA 95, 1.56).

GDP, and in particular GDP per capita, is one of the main indicators for economic analysis as well as spatial and/or temporal international comparisons. In order to facilitate these international comparisons, the GDP in national currency of each Member State is converted into a common currency (ECU until 1998, Euro from the beginning of 1999) by means of its official exchange rate. However, this does not necessarily reflect the actual purchasing power of each national currency on its economic territory, because the converted GDP is a function not only of the level of goods and services produced on the economic territory, but also of the general price level. Therefore, the simple use of the GDP converted into a common currency does not provide, in most cases, a correct indication of the volume of goods and services are necessary.

In order to remove the distortions due to price-level differences, transitive **purchasing power parities** (PPPs) are calculated and used as a factor of conversion (exchange rate from national currency to PPS). These parities are obtained as a weighted average of relative price ratios regarding a homogeneous basket of goods and services, comparable and representative for each Member State. The 'comparable volume' values of GDP obtained in this way is hence expressed in terms of purchasing power standards (PPS), a unit that is independent of any national currency.

Share of urban population

Country	Population total	Population in cities > 50'000 inhabitants	Urban
Unit	No.	No.	%
Base year	2000	2000	2000
AUSTRIA	8'103'000	2'371'400	29%
BELGIUM	10'239'000	3'319'000	32%
DENMARK	5'330'000	1'771'500	33%
FINLAND	5'171'000	2'085'100	40%
FRANCE	59'226'000	13'033'700	22%
GERMANY	82'164'000	32'583'300	40%
GREECE	10'543'000	4'027'600	38%
IRELAND	3'777'000	1'377'600	36%
ITALY	57'680'000	18'560'200	32%
LUXEMBOURG	436'000	79'800	18%
NETHERLANDS	15'864'000	7'867'000	50%
NORWAY	4'479'000	1'714'800	38%
PORTUGAL	9'998'000	2'019'300	20%
SPAIN	39'442'000	21'671'500	55%
SWEDEN	8'861'000	3'301'800	37%
SWITZERLAND	7'164'000	1'206'700	17%
UNITED KINGDOM	59'623'000	29'672'100	50%
Total	**388'100'000**	**146'662'400**	**38%**

Table 45 Percentage of urban population. Sources: www.world-gazetteer.com, EUROSTAT 2002

TRAFFIC VOLUMES

Data for road, aviation[20] and inland waterway transport volumes are based on TRENDS 1 (**TR**ansport and **EN**vironment **D**atabase **S**ystem Version 1), which is a EUROSTAT project funded by EU DG Transport. TRENDS 1 provide a range of transparent, consistent and comparable environmental pressure indicators caused by the various modes of transport. A complete set of data is available for:

› Modes of transport: Road, rail, shipping and air transport for different type of vehicles, passenger and freight transport.
› Countries: EUR 15 (Switzerland and Norway added separately).
› Environmental nuisances:
  › Air emissions (CO, CO_2, NMVOC, CH_4, NO_x etc.),
  › Noise emissions,

20 Air freight is estimated based on ICAO data.

› Waste production.

› Time span: 1990 – 2020.

TRENDS 1 data were compared within the database TREMOVE to other data sources as ACEA, OECD, EUROSTAT, National Statistics UK (int.), National Statistics AT (int.) and other National Statistics data. Traffic volumes for vehicles, passenger and freight transport are calculated with the **national principle** and not the domestic principle. This means that foreign vehicles, which drive within a certain country do not appear in the statistics.

›

Road transport

Table 46 shows vehicle kilometres by country from the TRENDS1 database for 2000.

Road mill. vkm - 2000		Vehicle type							
Country	Short Cut	Car (urban)	Car (non urban)	Buses	Coaches	Two-wheelers	LDV	HDV	Total
Austria	AT	21049	46850	344	86	3168	2465	15783	89745
Belgium	BE	20869	56423	268	67	1116	7479	11402	97624
Denmark	DK	14704	22056	656	164	633	3012	5566	46790
Finland	FI	14063	32815	494	124	403	3510	3407	54816
France	FR	111835	167753	2681	670	9211	78436	40538	411124
Germany	DE	203417	343403	3592	898	15487	34708	97289	698794
Greece	GR	22124	24888	224	224	8828	12815	7896	76998
Ireland	IE	4965	14895	210	53	272	1932	3782	26108
Italy	IT	105950	239966	2747	754	41766	35477	46868	473528
Luxembourg	LU	1748	2137	36	9	67	126	474	4597
Netherlands	NL	21916	42507	361	90	2036	189	16736	83836
Norway	NO	0	25907	283	71	657	2458	1329	30704
Portugal	PT	8465	26807	244	244	4662	8379	13405	62207
Spain	ES	69684	100275	679	679	5987	78210	33054	288569
Sweden	SE	16715	45192	700	175	1103	6136	5568	75588
Switzerland	CH	0	48492	200	122	1802	3252	2551	56419
United Kingdom	UK	161765	189898	3557	889	3387	38299	34279	432074
Total		799270	1430264	17276	5319	100584	316883	339927	3009521

Table 46

Passenger kilometre resp. tonne kilometres (TRENDS1 database) for year 2000 are listed in Table 47.

Road mill. pkm/tkm - 2000		VehType							
Country	Short Cut	Car (urban)	Car (non urban)	Buses	Coaches	Two-wheelers	LDV	HDV	Total
Austria	AT	31'994	71'213	7'823	1'956	3'548	1'849	171'843	290'226
Belgium	BE	20'869	56'423	7'703	1'925	1'250	5'609	69'956	163'736
Denmark	DK	25'879	38'984	12'693	3'173	709	2'259	53'533	137'230
Finland	FI	19'689	45'941	6'350	1'587	451	2'633	24'496	101'146
France	FR	206'797	310'196	68'553	17'135	10'317	58'827	230'652	902'477
Germany	DE	284'784	480'764	67'215	16'804	17'346	26'031	557'854	1'450'796
Greece	GR	39'822	44'798	8'547	8'548	9'887	9'611	67'642	188'856
Ireland	IE	7'001	21'002	2'353	588	304	1'449	32'810	65'506
Italy	IT	174'818	395'945	44'852	12'307	46'778	26'607	317'434	1'018'742
Luxembourg	LU	2'168	2'650	335	84	75	94	3'641	9'047
Netherlands	NL	35'600	69'049	8'426	2'107	2'280	142	145'058	262'662
Norway	NO		50'111	3'238	809	739	737	12'379	68'013
Portugal	PT	19'301	61'121	4'176	4'176	5'221	6'284	68'336	168'614
Spain	ES	175'604	252'694	17'253	17'257	6'705	58'658	219'131	747'301
Sweden	SE	26'911	72'759	6'884	1'720	1'235	4'602	39'095	153'207
Switzerland	CH	0	80'982	3'740	2'281	2'000	976	14'286	104'264
United Kingdom	UK	260'441	305'735	31'021	7'751	3'793	28'725	278'652	916'118
Total		1'331'679	2'360'364	301'162	100'208	112'639	235'092	2'306'797	6'747'941

Table 47

Rail data

With respect to rail data two major data sources are available. We compared rail transport volumes from the TRENDS1 database with the official UIC railway statistics. The available data frame found in the UIC statistics 2000 and 2001 (UIC 2002a and UIC 2003) is shown in Table 48.

2000		Diesel locomotives			Electric locomotives			Diesel railcars			Electric railcars			High Speed	All types of traction		
Country	Shortcut	Total	passenger trains	freigth trains	Total	passenger trains	freigth trains	Total	passenger trains	freigth trains	Total	passenger trains	freigth trains	0	Total	passenger trains	freigth trains
Unit: mill. train km																	
AUSTRIA	AT	7	4	3	98	51	47	12	12	0	24	24	0	n.a.	140	91	50
BELGIUM	BE	9	4	5	29	17	13	1	1	0	52	51	1	4	96	77	18
DENMARK 2)	DK	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0	n.a.	n.a.	0	n.a.	61	55	6
FINLAND	FI	12	5	7	25	15	10	0	0	0	7	7	0	1	45	28	17
FRANCE	FR	44	25	19	199	65	135	51	51	0	98	97	1	137	528	373	155
GERMANY	DE	151	111	40	591	401	190	103	103	0	73	73	0	66	985	755	230
GREECE	GR	6	5	1	0	0	0	10	10	0	0	0	0	n.a.	17	15	1
IRELAND	IE	12	9	3	0	0	0	2	2	0	2	2	0	n.a.	15	13	3
ITALY	IT	16	14	3	213	157	56	36	36	0	28	28	0	17	310	252	58
LUXEMBOURG	LU	1	0	1	2	1	1	0	0	0	5	5	0	n.a.	7	6	1
NETHERLANDS 2)	NL	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
NORWAY	NO	4	2	2	12	5	7	2	2	0	16	16	0	n.a.	34	25	9
PORTUGAL 2)	PT	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0	n.a.	n.a.	0	n.a.	40	32	8
SPAIN	ES	19	8	10	55	23	31	21	21	0	84	84	0	12	190	149	42
SWEDEN 2)	SE	0	0	0	0	0	0	0	0	0	-15	-15	0	15	0	0	0
SWITZERLAND 1)	CH	0	0	0	4	3	1	0	0	0	5	5	0	n.a.	140	108	32
UNITED KINGDOM 1)	UK	112	36	76	45	34	10	173	173	0	182	180	2	n.a.	512	424	88
TOTAL	TT	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	252	n.a.	n.a.	718

Data source: > UIC 2000, Rail statistics Tab 41
> UIC 2001, Rail statistics Tab 41

Remarks: 1) Data from UIC 2001 : marked yellow
2) No data found in UIC statistics

Table 48

Some differences exist between the mentioned two databases resp. there are missing data for some countries:

COUNTRIES MISSING IN RAIL STATISTICS (TRAIN KM)			
Source	**Missing country**	**Remarks**	**Actions**
UIC	Denmark Netherlands Portugal Sweden	Only UIC statistical for 2000 and 2001 data considered	TRENDS1 data were used
TRENDS1	Norway Switzerland	Both countries do not participate in the project.	Norway: UIC data were used Switzerland: UIC data used

Table 49

Another problem in the UIC statistics is that sub figures (i.e. traffic volumes by traction type) do not sum up to total values (sum train-km of all traction types). Therefore we merged the information in the two databases by calibrating the TRENDS1 dataset with the UIC statistical data. First, we calculate the calibration factor for each traction type. This means we simply calculate the proportional portion (percentage) from UIC values to

TRENDS1 values. In a second step, we multiplied the TRENDS traffic volumes and also emissions partitioned after traction type with the calibration factor.

		Diesel locomotives			Electric locomotives			Diesel railcars			Electric railcars			High Speed
		Total	passenger trains	freigth trains	Total	passenger trains	freigth trains	Total	passenger trains	freigth trains	Total	passenger trains	freigth trains	
		%	%	%	%	%	%	%	%	%	%	%	%	%
AUSTRIA	AT	54%	87%	34%	108%	104%	113%	126%	126%	0%	90%	90%	0%	n.a.
BELGIUM	BE	106%	103%	109%	105%	106%	104%	114%	114%	n.a.	98%	99%	75%	91%
DENMARK	DK	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0%	n.a.	n.a.	n.a.	n.a.
FINLAND	FI	100%	106%	97%	118%	120%	115%	n.a.	n.a.	n.a.	103%	103%	n.a.	38%
FRANCE	FR	119%	110%	134%	109%	108%	110%	116%	116%	n.a.	115%	116%	77%	94%
GERMANY	DE	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	n.a.	100%
GREECE	GR	102%	100%	112%	n.a.	n.a.	n.a.	104%	104%	n.a.	n.a.	n.a.	n.a.	n.a.
IRELAND	IE	97%	113%	65%	n.a.	n.a.	n.a.	119%	119%	n.a.	108%	108%	n.a.	n.a.
ITALY	IT	98%	95%	115%	99%	102%	90%	104%	104%	65%	71%	71%	62%	96%
LUXEMBOURG	LU	60%	6%	118%	118%	154%	73%	118%	118%	n.a.	114%	114%	n.a.	n.a.
NETHERLANDS	NL	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0%
NORWAY	NO	100%	100%	100%	100%	100%	100%	100%	100%	n.a.	100%	100%	n.a.	n.a.
PORTUGAL	PT	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
SPAIN	ES	134%	111%	161%	99%	117%	89%	135%	135%	n.a.	107%	107%	n.a.	81%
SWEDEN	SE	0%	0%	0%	0%	0%	0%	0%	0%	n.a.	-74%	-74%	n.a.	62%
SWITZERLAND	CH	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
UNITED KINGDOM	UK	386%	763%	312%	94%	79%	262%	103%	103%	0%	113%	112%	569%	n.a.

Table 50 Deviations between UIC and TRENDS data (train-km (UIC)/train-km (TRENDS))

At the end of the described procedure, we obtained a TRENDS1 dataset calibrated with the UIC data for train km:

2000		**All types of traction**			Total Diesel traction			Total Electric traction		
Country	Shortcut	Total	passenger trains	freigth trains	Total Diesel traction	Passenger	Freight	Total Electric traction	Passenger	Freight
Unit		mill. train km	mill. train km	mill. train km	mill. train km	mill. train km	mill. train km	mill. train km	mill. train km	mill. train km
Base year										
AUSTRIA	AT	140	91	50	19	16	3	122	75	47
BELGIUM	BE	96	77	18	10	5	5	85	72	13
DENMARK	DK	62	55	7	39	35	4	23	20	3
FINLAND	FI	45	28	17	12	5	7	33	23	10
FRANCE	FR	528	373	155	95	75	19	434	298	136
GERMANY	DE	985	755	230	254	214	40	730	540	190
GREECE	GR	17	15	1	17	15	1	0	0	0
IRELAND	IE	15	13	3	13	11	3	2	2	0
ITALY	IT	310	252	58	52	50	3	258	202	56
LUXEMBOURG	LU	7	6	1	1	0	1	6	6	1
NETHERLANDS	NL	125	118	8	12	11	1	113	107	6
NORWAY	NO	34	25	9	7	4	2	27	21	7
PORTUGAL	PT	46	38	8	20	17	3	26	21	5
SPAIN	ES	190	149	42	40	29	10	151	119	31
SWEDEN	SE	91	56	35	10	7	3	81	48	32
SWITZERLAND	CH	140	108	32	8	6	2	132	102	30
UNITED KINGDOM	UK	512	424	88	285	209	76	226	214	12
TOTAL	TT	3'343	2'581	762	894	711	183	2'448	1'869	579

Table 51 Transport volume in million train km

With the same calibration factors we adjust passenger km and tonnes km from the TRENDS database. Switzerland figures are found in BFS 2000 and UIC 2002a. Data for Norway is available in the Statistical Yearbook of Norway (SYN 2002).

2000		All types of traction			Total Diesel traction			Total Electric traction		
Country	Shortcut	Total	passenger trains	freigth trains	Total Diesel traction	Passenger	Freight	Total Electric traction	Passenger	Freight
Unit		mio. pkm/tkm	mio. pkm	mio. tkm	mio. pkm/tkm	mio. pkm	mio. tkm	mio. pkm/tkm	mio. pkm	mio. tkm
Base year										
AUSTRIA	AT	29'521	10'290	19'231	2'342	1'310	1'032	27'179	8'980	18'199
BELGIUM	BE	16'281	8'819	7'462	3'018	870	2'148	13'263	7'949	5'314
DENMARK	DK	5'952	4'062	1'890	3'569	2'579	991	2'383	1'483	900
FINLAND	FI	13'865	4'040	9'825	5'090	889	4'201	8'774	3'151	5'623
FRANCE	FR	128'323	79'493	48'830	20'521	14'458	6'062	107'802	65'035	42'768
GERMANY	DE	153'800	75'500	78'300	33'061	20'904	12'157	120'739	54'596	66'143
GREECE	GR	1'818	1'673	144	1'818	1'673	144	0	0	0
IRELAND	IE	2'179	1'765	414	2'095	1'681	414	84	84	0
ITALY	IT	65'919	49'524	16'395	4'977	4'271	707	60'941	45'253	15'688
LUXEMBOURG	LU	1'148	486	662	393	19	374	755	467	288
NETHERLANDS	NL	14'984	12'671	2'313	1'429	994	435	13'556	11'677	1'879
NORWAY	NO	5'051	2'600	2'451	1'219	572	646	4'504	2'700	1'805
PORTUGAL	PT	5'580	3'633	1'947	2'479	1'656	823	3'101	1'977	1'124
SPAIN	ES	28'552	18'960	9'593	6'377	3'987	2'390	22'175	14'973	7'202
SWEDEN	SE	21'818	5'154	16'664	1'610	371	1'238	20'209	4'783	15'426
SWITZERLAND	CH	24'762	14'104	10'658	0	0	0	0	0	0
UNITED KINGDOM	UK	72'792	47'213	25'579	46'035	23'584	22'450	26'757	23'629	3'128
TOTAL	TT	592'345	339'987	252'358	136'032	79'818	56'214	432'223	246'737	185'486

Table 52 Transport volumes in million pkm resp. tkm for rail traffic used in the calculations.

Aviation data

Regarding aviation transport data two possible data sources are available: TRENDS 1 data as well as ICAO statistical data, which were used for the last UIC study (base year 1995, see INFRAS/IWW 2000). The TRENDS1 database only contains air passenger transport data. Data for air freight transport were not available. However, in air transport there is no clear distinction possible between passenger and freight transport, since most passenger aircrafts also carry a considerable amount of freight. As a result, emission data of air transport in TRENDS1 include also emissions of freight transport with respect to those aircrafts which carry passenger and freight. Only freight-only air transport services are not included.

The second possible data source for air transport data are ICAO statistical data which was used in the INFRAS/IWW (2000) study. Based on the airport traffic (aircraft movements, passenger and freight data), additional information on the number of passengers and amount of freight and mail to domestic and international destinations and assumptions on the average flight distance traffic volumes and transport performances figures could be derived.

The following table show the results for TRENDS1:

Country	Shortcut	pkm - Take Off, Cruise and Landing				vkm - Take Off, Cruise and Landing			
		AirP/Short Haul	AirP/Medium Haul	Short + Medium Haul	AirP/Long Haul	AirP/Short Haul	AirP/Medium Haul	Short + Medium Haul	AirP/Long Haul
Unit		mill. pkm	mill. pkm	mill. pkm	mill. pkm	mill. vkm	mill. vkm	mill. vkm	mill. vkm
Base year									
AUSTRIA	AT	1'382	6'220	7'602	16'113	42'011	445'541	487'552	3'045'269
BELGIUM	BE	2'893	6'696	9'589	40'147	75'576	419'938	495'514	8'904'917
DENMARK	DK	1'634	9'898	11'532	18'907	44'494	725'201	769'695	4'000'702
FINLAND	FI	1'623	2'679	4'302	13'003	44'641	195'154	239'795	2'653'149
FRANCE	FR	12'521	30'250	42'771	169'089	408'674	2'116'447	2'525'121	47'116'798
GERMANY	DE	16'745	26'725	43'470	218'860	571'478	1'833'248	2'404'726	57'096'649
GREECE	GR	2'119	1'540	3'659	41'823	59'894	117'876	177'770	8'679'894
IRELAND	IE	3'306	2'678	5'984	15'258	115'728	190'848	306'576	3'967'212
ITALY	IT	7'941	24'103	32'044	83'786	276'507	1'731'030	2'007'536	18'082'535
LUXEMBOURG	LU	0	0	0	0	n.b.	n.b.	0	n.b.
NETHERLANDS	NL	4'229	7'798	12'027	101'111	132'656	559'669	692'325	32'489'420
NORWAY	NO	0	0	0	0	n.b.	n.b.	0	n.b.
PORTUGAL	PT	586	2'382	2'968	31'109	16'810	179'648	196'458	6'539'452
SPAIN	ES	8'914	11'000	19'914	161'633	275'239	813'835	1'089'075	33'813'899
SWEDEN	SE	4'856	4'854	9'710	23'741	151'182	323'339	474'521	4'555'703
SWITZERLAND	CH	0	0	0	0	n.b.	n.b.	0	n.b.
UNITED KINGDOM	UK	14'804	29'076	43'880	337'461	480'823	2'033'204	2'514'027	96'212'136
TOTAL	**TT**	**83'552**	**165'898**	**249'450**	**1'272'042**	**2'695'714**	**11'684'977**	**14'380'691**	**327'157'735**

Table 53 TRENDS1 air transport data. There is no data available for Luxembourg, Norway and Switzerland. To improve comparability to ICAO data we sum up Short+Medium Haul services which correspond more or less to domestic transport in the ICAO methodology.

TRENDS 1 data for passenger air transport are based on EUROCONTROL activity movements. These data contain movements per aircraft type and origin/destination pair.

Emissions and fuel consumption as well as traffic indicators like passenger kilometres and vehicle kilometres have been found in the TRENDS 1 dataset per country (EU15) and per three distance classes:

› short haul: < 500 km
› medium haul: 500 – 1000 km
› long haul: > 1000 km

As well as for:

› take off (altitude < 3000 ft at departure)
› cruise (altitude > 3000 ft)
› landing (altitude < 3000 ft at destination).

The split between passenger and freight traffic was not made in TRENDS 1, due to the lack of freight data reported. No freight data is included in the TRENDS aviation database. This means on the other hand that all emissions from aviation are allocated to passenger transport.

One source that publishes passenger km as well as ton km is the AEA data. A cross check made by TRENDS showed that the AEA data seem to underestimate actual passenger km flown by an order of 40 – 100. Since no other source for freight was available to check the reliability of the AEA freight data, it must be assumed that this data source underestimates actual tonne km as well.

Country	Shortcut	LTO			pkm			tkm		
		Commercial Air Transport national	intern.	total	national	intern.	total	national	intern.	total
Unit		1'000 LTO	1'000 LTO	1'000 LTO	mill. pkm	mill. pkm	mill. pkm	mill. tkm	mill. tkm	mill. tkm
Base year		2000	2000	2000	2000	2000	2000	2000	2000	2000
AUSTRIA	AT	8.3	84.8	93.1	149	15'810	15'960	0.2	184.5	185.6
BELGIUM	BE	9.0	143.5	152.5	2	30'121	30'123	0.1	961.8	962.4
DENMARK	DK	26.4	123.5	149.9	596	22'642	23'238	13.7	521.1	585.1
FINLAND	FI	32.0	46.5	78.4	913	9'750	10'662	2.1	124.9	134.7
FRANCE	FR	321.7	401.8	723.6	13'581	89'404	102'985	72.7	1'714.4	2'053.5
GERMANY	DE	284.9	549.0	833.9	12'245	134'086	146'331	109.0	3'045.3	3'553.8
GREECE	GR	47.0	40.3	87.3	1'567	9'653	11'220	6.3	102.6	132.2
IRELAND	IE	20.9	84.9	105.8	340	22'551	22'891	6.5	208.5	238.6
ITALY	IT	187.4	236.2	423.5	8'612	54'309	62'921	49.0	775.6	1'004.1
LUXEMBOURG	LU	0.0	25.3	25.3	0	2'318	2'318	0.0	701.1	701.1
NETHERLANDS	NL	3.9	203.5	207.5	51	54'740	54'791	0.0	1'774.4	1'774.4
NORWAY	NO	135.2	60.4	195.6	4'771	11'984	16'755	17.4	80.1	161.1
PORTUGAL	PT	18.8	81.3	100.0	1'280	19'965	21'245	11.0	183.3	234.8
SPAIN	ES	302.3	319.3	621.6	13'463	108'027	121'490	68.9	455.7	777.1
SWEDEN	SE	83.1	106.5	189.6	2'813	21'185	23'997	12.6	397.2	456.0
SWITZERLAND	CH	25.0	204.9	230.0	698	41'511	42'210	5.4	679.0	704.3
UNITED KINGDOM	UK	274.4	615.5	889.9	9'823	196'605	206'428	66.8	3'196.3	3'508.1
TOTAL	TT	**1'780.1**	**3'327.0**	**5'107.0**	**70'902**	**844'662**	**915'564**	**441.6**	**15'105.7**	**17'166.7**

Source: ICAO Digest of Statistics No 494: AIRPORT TRAFFIC 2000 (Part B, yellow pages): SUM OF ALL AIRPORTS
pkm and tkm: passenger * av. Flight distance (national: 300 km; international: 1400 km)
1) Denmark: Allocation for freight and mail based upon passenger data, Freight data 1999, Mail data 1995
2) France/Switzerland: Basel/Mulhouse: all movements, passenger and freight/mail data are allocated 50/50 to France and Switzerland
3) Ireland/Italy: mail allocation Cork+Dublin based on freight data
4) Switzerland: mail allocation Zurich based on freight data

Table 54 Air transport data based on ICAO statistical data.

We suggest using trends passenger transport data (pkm, emissions) and include freight transport according to the split tkm/pkm in Table 54.
We assumed that one passenger is equal to 190 kg freight (INFRAS/IWW 2000).

Inland waterborne transport

TRENDS1 provide specific traffic volume data for inland waterborne freight transport. Table 55 shows the available data:

Country	Shortcut	Inland Waterways	
		mio tkm	mio vkm
Base year		2000	2000
AUSTRIA	AT	2'025	2'025
BELGIUM	BE	6'561	6'561
DENMARK	DK	0	n.b.
FINLAND	FI	506	506
FRANCE	FR	7'624	7'624
GERMANY	DE	62'000	62'000
GREECE	GR	0	n.b.
IRELAND	IE	0	n.b.
ITALY	IT	125	125
LUXEMBOURG	LU	327	327
NETHERLANDS	NL	37'630	37'630
NORWAY	NO	0	n.b.
PORTUGAL	PT	0	n.b.
SPAIN	ES	0	n.b.
SWEDEN	SE	0	n.b.
SWITZERLAND	CH	0	n.b.
UNITED KINGDOM	UK	200	200
TOTAL	TT	116'998	116'998

Table 55 Inland waterborne transport data in EU17.

EMISSIONS

Road

The TRENDS1 database delivers the following total emissions for road transport:

		Passenger							
Country	Shortcut	Em_CH4	Em_CO	Em_CO2	Em_HC	Em_NMHC	Em_NOx	Em_PM	Em_SO2
Unit		[t/a]	[t/a]	[t/a]	[t/a]	[t/a]	[t/a]	[t/a]	[t/a]
Base year									
AUSTRIA	AT	6'494	522'429	13'529'280	65'068	58'574	59'731	2'779	1'706
BELGIUM	BE	4'774	385'661	16'344'914	45'934	41'161	57'923	4'258	2'240
DENMARK	DK	3'690	288'098	7'428'940	44'024	40'333	42'106	689	999
FINLAND	FI	3'806	374'955	8'993'059	44'559	40'753	51'015	1'263	913
FRANCE	FR	24'830	2'160'900	59'113'923	345'193	320'363	300'228	11'550	9'140
GERMANY	DE	69'938	5'656'198	122'938'365	565'220	495'282	507'527	20'979	16'456
GREECE	GR	5'783	672'565	10'947'530	129'513	123'730	53'200	987	1'034
IRELAND	IE	1'601	158'680	3'882'827	30'409	28'808	21'907	416	671
ITALY	IT	34'357	3'800'816	73'890'079	669'152	634'795	401'127	13'124	10'296
LUXEMBOURG	LU	371	26'301	797'000	2'492	2'120	2'256	111	87
NETHERLANDS	NL	8'453	612'483	14'306'825	67'902	59'449	48'192	2'359	1'903
NORWAY	NO	4'004	340'453	6'534'213	41'395	37'391	28'584	494	1'023
PORTUGAL	PT	4'523	425'918	7'385'299	71'613	67'090	37'681	844	886
SPAIN	ES	19'918	2'183'152	38'404'688	288'956	269'038	187'557	13'527	5'568
SWEDEN	SE	9'490	806'051	15'599'595	96'771	87'282	68'716	1'200	2'447
SWITZERLAND	CH	1'552	200'207	10'535'132	23'671	22'118	27'437	672	1'049
UNITED KINGDOM	UK	47'789	4'179'099	85'595'362	538'418	490'629	353'820	8'337	13'715
TOTAL	**TT**	**251'374**	**22'793'966**	**496'227'030**	**3'070'290**	**2'818'915**	**2'249'006**	**83'589**	**70'134**

Table 56 Total emissions for passenger road transport.

		Freight							
Country	Shortcut	Em_CH4	Em_CO	Em_CO2	Em_HC	Em_NMHC	Em_NOx	Em_PM	Em_SO2
Unit		[t/a]	[t/a]	[t/a]	[t/a]	[t/a]	[t/a]	[t/a]	[t/a]
Base year									
AUSTRIA	AT	1'269	52'806	13'423'697	19'265	17'996	129'157	8'382	2'514
BELGIUM	BE	788	67'492	8'730'398	19'675	18'888	73'023	6'299	1'615
DENMARK	DK	543	44'098	5'160'935	10'373	9'830	43'668	3'019	941
FINLAND	FI	280	24'020	3'096'029	6'832	6'553	26'226	2'524	513
FRANCE	FR	4'833	633'326	45'386'942	128'854	124'020	359'806	36'629	8'081
GERMANY	DE	6'444	483'914	64'135'081	165'456	159'012	558'609	52'603	11'990
GREECE	GR	1'105	146'769	9'257'713	28'220	27'116	81'133	6'072	1'588
IRELAND	IE	251	14'855	2'992'780	4'917	4'666	25'968	1'953	564
ITALY	IT	3'712	352'494	39'182'580	88'261	84'549	317'433	26'179	7'166
LUXEMBOURG	LU	36	2'580	334'700	677	641	2'888	192	61
NETHERLANDS	NL	1'010	38'009	12'208'616	19'464	18'454	104'611	7'266	2'323
NORWAY	NO	391	66'255	1'996'728	8'723	8'332	16'483	1'072	354
PORTUGAL	PT	654	39'553	8'775'738	19'273	18'619	70'409	8'478	1'235
SPAIN	ES	5'327	803'945	46'492'493	121'679	116'352	372'614	36'930	6'724
SWEDEN	SE	1'018	167'058	5'469'279	22'755	21'737	45'642	3'021	977
SWITZERLAND	CH	143	19'878	3'224'612	3'906	3'762	23'987	1'139	553
UNITED KINGDOM	UK	5'080	640'119	36'637'652	100'223	95'143	264'970	20'076	6'305
TOTAL	**TT**	**32'884**	**3'597'170**	**306'505'974**	**768'555**	**735'670**	**2'516'625**	**221'833**	**53'505**

Table 57 Total emissions for freight road transport.

Rail

Total emissions for rail transport (passenger and freight) for the year 2000 are listed in Table 58 and Table 59.

		Passenger							
Country	Shortcut	Em_CH4	Em_CO	Em_CO2	Em_HC	Em_NMHC	Em_NOx	Em_PM	Em_SO2
Unit		[t/a]	[t/a]	[t/a]	[t/a]	[t/a]	[t/a]	[t/a]	[t/a]
Base year									
AUSTRIA	AT	250	199	241'721	43	50	1'100	71	286
BELGIUM	BE	1'023	157	427'087	24	52	1'687	143	2'302
DENMARK	DK	694	925	463'508	250	19	5'336	334	1'023
FINLAND	FI	308	135	182'493	27	15	813	54	231
FRANCE	FR	927	1'595	902'501	424	82	9'555	687	5'268
GERMANY	DE	10'186	3'587	5'044'435	837	206	22'490	2'187	21'476
GREECE	GR	0	372	110'741	104	0	1'964	119	134
IRELAND	IE	24	194	68'446	54	2	1'052	65	155
ITALY	IT	942	962	1'571'533	191	887	8'240	564	8'477
LUXEMBOURG	LU	5	5	19'274	1	3	27	1	14
NETHERLANDS	NL	1'995	410	967'089	70	163	2'747	176	1'031
NORWAY	NO	43	229	103'984	61	13	1'229	76	144
PORTUGAL	PT	313	282	223'536	71	47	1'772	132	1'190
SPAIN	ES	1'835	841	974'209	203	96	6'306	578	7'652
SWEDEN	SE	42	104	66'539	26	12	571	36	99
SWITZERLAND	CH	0	71	52'711	64	0	360	16	76
UNITED KINGDOM	UK	5'392	5'587	3'539'275	1'474	237	35'224	2'506	18'882
TOTAL	**TT**	**23'979**	**15'655**	**14'959'082**	**3'923**	**1'884**	**100'473**	**7'745**	**68'439**

Table 58 Total emissions for passenger rail transport.

Country	Shortcut	Freight Em_CH4	Em_CO	Em_CO2	Em_HC	Em_NMHC	Em_NOx	Em_PM	Em_SO2
Unit		[t/a]	[t/a]	[t/a]	[t/a]	[t/a]	[t/a]	[t/a]	[t/a]
Base year									
AUSTRIA	AT	248	208	242'715	46	49	1'150	74	288
BELGIUM	BE	188	232	138'690	61	10	1'380	91	495
DENMARK	DK	0	240	71'382	67	0	1'266	77	86
FINLAND	FI	185	376	197'654	99	9	2'048	127	245
FRANCE	FR	273	795	362'581	216	24	4'531	306	1'668
GERMANY	DE	5'016	1'831	2'503'179	430	101	11'414	1'098	10'599
GREECE	GR	0	21	6'401	6	0	114	7	8
IRELAND	IE	0	81	24'090	23	0	427	26	29
ITALY	IT	318	141	476'514	13	300	1'813	132	2'800
LUXEMBOURG	LU	1	46	16'763	13	1	245	15	19
NETHERLANDS	NL	124	60	70'339	14	10	351	22	76
NORWAY	NO	6	52	20'142	14	2	280	17	27
PORTUGAL	PT	98	144	86'494	38	15	848	59	392
SPAIN	ES	532	408	331'233	105	28	2'695	220	2'276
SWEDEN	SE	46	110	71'348	27	14	603	38	106
SWITZERLAND	CH	0	52	38'798	47	0	265	11	56
UNITED KINGDOM	UK	397	3'077	1'054'199	855	17	16'668	1'037	2'349
TOTAL	**TT**	**7'431**	**7'874**	**5'712'524**	**2'074**	**579**	**46'096**	**3'357**	**21'520**

Table 59 Total emissions for freight rail transport.

Other transport means

Total Emissions for air transport (passenger) for the year 2000 are shown in Table 60. This data set comes also out of the TRENDS1 database.

Country	Shortcut	Passenger Em_CH4	Em_CO	Em_CO2	Em_HC	Em_NMHC	Em_NOx	Em_PM	Em_SO2
Unit		[t/a]	[t/a]	[t/a]	[t/a]	[t/a]	[t/a]	[t/a]	[t/a]
Base year									
AUSTRIA	AT	0	3'435	3'197'688	1'468	0	10'235	0	1'015
BELGIUM	BE	0	5'397	6'128'599	1'785	0	19'347	0	1'946
DENMARK	DK	0	3'852	4'086'354	1'178	0	12'488	0	1'297
FINLAND	FI	0	2'250	2'386'055	883	0	7'781	0	757
FRANCE	FR	0	22'433	28'639'153	9'144	0	91'274	0	9'092
GERMANY	DE	0	26'659	34'255'146	10'213	0	108'588	0	10'875
GREECE	GR	0	4'987	5'852'426	1'688	0	18'253	0	1'858
IRELAND	IE	0	3'128	3'162'770	1'018	0	10'580	0	1'004
ITALY	IT	0	12'893	15'716'767	4'539	0	51'620	0	4'989
LUXEMBOURG	LU	0	197	307'603	65	0	879	0	98
NETHERLANDS	NL	0	9'102	14'224'165	3'011	0	40'650	0	4'516
NORWAY	NO	0	3'404	3'395'621	1'057	0	10'674	0	1'078
PORTUGAL	PT	0	3'201	4'201'503	1'191	0	14'144	0	1'334
SPAIN	ES	0	18'255	24'219'012	6'556	0	82'319	0	7'689
SWEDEN	SE	0	4'726	4'714'182	1'467	0	14'819	0	1'497
SWITZERLAND	CH	0	8'941	8'324'370	3'821	0	26'645	0	2'643
UNITED KINGDOM	UK	0	34'629	50'025'943	13'678	0	158'383	0	15'881
TOTAL	**TT**	**0**	**167'490**	**212'837'358**	**62'762**	**0**	**678'678**	**0**	**67'567**

Table 60 Total emissions for passenger air transport.

Country	Shortcut	Inland Waterways: Gas Oil/Medium Speed Em_CH4	Em_CO	Em_CO2	Em_HC	Em_NMHC	Em_NOx	Em_PM	Em_SO2
Unit		[t/a]	[t/a]	[t/a]	[t/a]	[t/a]	[t/a]	[t/a]	[t/a]
Base year									
AUSTRIA	AT	2	60	62'570	60	58	1'199	80	68
BELGIUM	BE	8	194	202'726	194	188	3'886	259	220
DENMARK	DK	0	0	0	0	0	0	0	0
FINLAND	FI	1	15	15'635	15	14	300	20	17
FRANCE	FR	9	226	235'572	226	218	4'516	301	256
GERMANY	DE	73	1'836	1'915'721	1'836	1'775	36'723	2'448	2'081
GREECE	GR	0	0	0	0	0	0	0	0
IRELAND	IE	0	0	0	0	0	0	0	0
ITALY	IT	0	4	3'862	4	4	74	5	4
LUXEMBOURG	LU	0	10	10'092	10	9	193	13	11
NETHERLANDS	NL	45	1'114	1'162'719	1'114	1'077	22'289	1'486	1'263
NORWAY	NO	0	0	0	0	0	0	0	0
PORTUGAL	PT	0	0	0	0	0	0	0	0
SPAIN	ES	0	0	0	0	0	0	0	0
SWEDEN	SE	0	0	0	0	0	0	0	0
SWITZERLAND	CH	0	0	0	0	0	0	0	0
UNITED KINGDOM	UK	0	6	6'180	6	6	118	8	7
TOTAL	**TT**	**139**	**3'465**	**3'615'076**	**3'465**	**3'349**	**69'299**	**4'620**	**3'927**

Table 61 Total emissions for freight inland waterborne transport (TRENDS1).

EMISSION FACTORS

EMISSION FACTORS BY VEHICLE TYPE					
Vehicle type	**CO_2** g/pkm ; g/tkm	**CO_2** g/vkm	**PM10 (exhaust emissions)** g/pkm ; g/tkm	**PM10 (exhaust emissions)** g/vkm	**PM10 (non-exhaust emissions)** g/vkm
Road					
Pass. Car non urban	192.9	144	0.01	0.02	0.045
Passenger Car urban	87.3	322	0.03	0.06	0.045
Two-Wheelers	83.7	94	0	0	0.0165
Bus (Diesel)	67.6	1'180	0.04	0.708	0.653
Coaches (Diesel)	35.0	656	0.02	0.313	0.65.
LDV (all techniques)	410	304	0.32	0.24	0.059
HDV (Diesel)	91.1	615	0.06	0.431	0.653
Rail					
Pass. Locomotive & Railcar (Diesel)	50.8	5'814	0.05	6.24	3.0
Pass. Locomotive & Railcar (electric)	38.7	5'389	0.01	1.64	3.0
High Speed Train (electric)	15.7	2'804	0.01	0.92	3.0
Freight Locomotive & Railcar (Diesel)	38.0	11'845	0.04	4.94	17.0
Freight Locomotive & Railcar (electric)	19.0	5'942	0.01	1.72	17.0
Other Transport Means					
Pass. Aviation	132	18'621	-	-	-
Freight. Aviation	673	-	-	-	-
Waterways	31	20'084	0.04	25.67	-

Table 62 Emission factors by vehicle type for CO_2 and PM10 (exhaust and non-exhaust emissions) based on the TRENDS1 database.

The following table shows the relevant data used to calculate emission factors for non-exhaust emissions in rail transport. Data calculation is based on BUWAL 2003, Train-km for

2000 are taken from national public transport statistics, since UIC statistics only cover train-kilometres of UIC members in Switzerland.
(http://www.statistik.admin.ch/stat_ch/ber11/dtfr11c.htm)

NON EXHAUST PM10 EMISSIONS IN RAIL TRANSPORT CALCULATION BASED ON BUWAL 2003			
	Passenger	**Freight**	**Total**
Unit Emissions	*t/a*	*t/a*	*t/a*
Total Emissions 2000			
Brake abrasion	84.0	329.0	413.0
Track abrasion	170.0	103.0	273.0
Wheel abrasion	77.0	47.0	124.0
Contact line abrasion	11.0	7.0	18.0
Exhaust (diesel engines only)	0.0	45.0	45.0
Resuspension	79.0	48.0	127.0
Total emissions	421.0	579.0	1000.0
Non-exhaust emissions	**421.0**	**534.0**	**955.0**
Total Factors			
Train-km Switzerland (1'000 km)	140'692.0	31'434.0	172'126.0
Unit Emission factors	*g/Train-km*	*g/Train-km*	*g/Train-km*
Emission factors Non-exhaust emissions	3.0	17.0	5.5

Table 63 Non-exhaust PM10 emissions for rail transport in Switzerland. Calculation used to estimate European Non-exhaust emission factors for rail transport.

The study on non-exhaust emissions for Switzerland is still going on with the general aim to verify the so far published data.

ACCIDENTS

Road Accident Data

Road Accident Data was taken from the IRTAD database (IRTAD 2003). There is no detailed information on accidents of HDV and LDV available. Fatalities and Injuries are reported within the IRTAD database from a victim's perspective, i.e. there is no information of the responsible causer of an accident available.

			Road						
No.	Country	Shortcut	Urban Roads	Interurban roads (=c+d+e)	Motorways	Highways, Main or National Roads	Other roads	Regional roads (=d+e)	Total
	Unit		Accidents with injuries	Accidents with injuries	Accidents with injuries	Accidents with injuries	Accidents with injuries	Accidents with injuries	Accidents with injuries
	Base year		2000	2000	2000	2000	2000	2000	2000
	Column		a	b	c	d	e	f	g
1	AUSTRIA	AT	25'400	16'726	2'466	6'985	7'275	14'260	42'126
2	BELGIUM	BE	24'860	24'204	4'713	13'208	6'283	19'491	49'065
3	DENMARK	DK	4'368	2'978	331	739	1'908	2'647	7'346
4	FINLAND	FI	3'734	2'899	152	1'207	1'540	2'747	6'633
5	FRANCE	FR	80'574	40'649	7'401	8'731	24'517	33'248	121'223
6	GERMANY	DE	245'470	137'479	25'578	38'754	73'147	111'901	382'949
7	GREECE	GR	16'059	0	0	0	0	6'606	23'001
8	IRELAND	IE	4'330	3'427	46	1'333	2'048	3'381	7'757
9	ITALY	IT	158'215	53'726	13'396	0	0	40'330	211'941
10	LUXEMBOURG	LU	362	543	111	0	0	432	905
11	NETHERLANDS	NL	25'202	12'745	2'767	4'951	5'027	9'978	37'947
12	NORWAY	NO	2'945	5'495	0	0	0	0	8'440
13	PORTUGAL	PT	30'042	14'117	1'918	8'667	3'532	12'199	44'159
14	SPAIN	ES	57'009	44'720	3'121	0	0	0	101'729
15	SWEDEN	SE	9'010	6'760	1'128	0	0	0	15'770
16	SWITZERLAND	CH	15'094	8'643	2'256	4'406	1'981	6'387	23'737
17	UNITED KINGI	UK	176'406	65'711	9'368	0	0	56'343	242'117
	Total		**879'080**	**440'822**	**74'752**	**88'981**	**127'258**	**319'950**	**1'326'845**

Table 64 Accident data road transport. Number of accidents with injuries 2000. Source: IRTAD 2003

			Road					
			Casualties by road use type					
No.	Country	Shortcut	Pedestrians	Cyclists	Motorcycles	Passenger cars and vans	Other transport means (LDV/HGV)	Total
	Unit		Fatalities	Fatalities	Fatalities	Fatalities	Fatalities	Fatalities
	Base year		2000	2000	2000	2000	2000	2000
	Column							
1	AUSTRIA	AT	140	62	156	549	69	976
2	BELGIUM	BE	142	134	182	922	80	1'460
3	DENMARK	DK	99	58	71	235	35	498
4	FINLAND	FI	62	53	19	224	38	396
5	FRANCE	FR	838	270	1'392	5'291	288	8'079
6	GERMANY	DE	993	659	1'102	4'396	353	7'503
7	GREECE	GR	375	22	502	891	245	2'035
8	IRELAND	IE	85	10	39	260	21	415
9	ITALY	IT	848	371	1'229	3'535	427	6'410
10	LUXEMBOURG	LU	11	1	8	53	2	75
11	NETHERLANDS	NL	106	198	196	513	69	1'082
12	NORWAY	NO	47	13	46	224	11	341
13	PORTUGAL	PT	382	55	435	899	89	1'860
14	SPAIN	ES	898	84	866	3'289	639	5'776
15	SWEDEN	SE	73	47	49	393	29	591
16	SWITZERLAND	CH	130	48	111	273	30	592
17	UNITED KINGI	UK	889	131	612	1'784	164	3'580
	Total		**6'118**	**2'216**	**7'015**	**23'731**	**2'589**	**41'669**

Table 65 Accident data road transport. Number of fatalities 2000. Source: IRTAD 2003

Data on injuries is only available for selected countries for 2000.

			Road					
			Casualties by road use type					
No.	Country	Shortcut	Pedestrians	Cyclists	Motorcycles	Passenger cars and vans	Other transport means (LDV/HGV)	Total
	Unit		Severe injuries	Severe injuries	Severe injuries	Severe injuries	Severe injuries	Severe injuries
	Base year		2000	2000	2000	2000	2000	2000
	Column							
1	AUSTRIA	AT	-	-	-	-	-	-
2	BELGIUM	BE	621	971	1'980	5'701	526	9'799
3	DENMARK	DK	436	658	839	2'139	294	4'366
4	FINLAND	FI	-	-	-	-	-	-
5	FRANCE	FR	-	-	-	-	-	-
6	GERMANY	DE	11'932	15'586	17'579	52'759	4'560	102'416
7	GREECE	GR	-	-	-	-	-	-
8	IRELAND	IE	-	-	-	-	-	-
9	ITALY	IT	-	-	-	-	-	-
10	LUXEMBOURG	LU	-	-	-	-	-	-
11	NETHERLANDS	NL	759	2'263	2'808	5'030	647	11'507
12	NORWAY	NO	165	80	205	804	11	1'265
13	PORTUGAL	PT	1'365	166	1'905	2'774	705	6'915
14	SPAIN	ES	3'288	475	7'323	14'233	2'445	27'764
15	SWEDEN	SE	-	-	-	-	-	-
16	SWITZERLAND	CH	-	-	-	-	-	-
17	UNITED KINGI	UK	-	-	-	-	-	-
	Total		**18'566**	**20'199**	**32'639**	**83'440**	**9'188**	**164'032**

Table 66 Accident data road transport. Number of severe injuries 2000. Source: IRTAD 2003

Rail Accident Data

Rail Accident Data were taken from official UIC statistics (UIC 2002c). Number of fatalities and injuries for the calculation of accident costs are based on a 7 years time series 1994-2000. The following tables show the most recent data for 1999 and 2000:

No.	Country	Shortcut	Rail 2000					
			Casualties by accident type					
No.	Country	Shortcut	Collisions and derailments	Other accidents	Per 1 Bill. Pkm	Collisions and derailments	Other accidents	Per 1 Bill. Pkm
	Unit		Fatalities	Fatalities	Fatalities	Injuries	Injuries	Injuries
	Base year		2000	2000	2000	2000	2000	2000
	Column							
1	AUSTRIA	AT	0	4	0.49	0	12	1.46
2	BELGIUM	BE	0	3	0.39	6	6	1.55
3	DENMARK	DK	...	...	...	...	...	...
4	FINLAND	FI	0	2	0.59	0	3	0.88
5	FRANCE	FR	2	13	0.22	0	21	0.30
6	GERMANY	DE	9	29	0.51	170	54	3.03
7	GREECE	GR	...	...	...	...	...	...
8	IRELAND	IE	0	2	1.44	0	0	0.00
9	ITALY	IT	0	8	0.18	3	27	0.69
10	LUXEMBOURG	LU	0	0	0.00	0	0	0.00
11	NETHERLANDS	NL	...	...	...	...	...	...
12	NORWAY	NO	16	0	6.07	23	0	8.73
13	PORTUGAL	PT	0	2	0.00	2	27	0.00
14	SPAIN	ES	0	0	0.00	1	0	0.05
15	SWEDEN	SE	0	0	0.00	2	...	...
16	SWITZERLAND	CH	0	2	0.16	0	9	0.70
17	UNITED KINGI	UK	10	3	0.00	17	46	0.00
	Total		**37**	**68**	**10**	**224**	**205**	**544**

Table 67 Accident data rail transport 2000. Fatalities and Injuries 2000. Source: IRTAD 2003. Remark: ...: no data available for the respective year.

			Rail 1999					
			Casualties by accident type					
No.	Country	Shortcut	Collisions and derailments	Other accidents	Per 1 Bill. Pkm	Collisions and derailments	Other accidents	Per 1 Bill. Pkm
	Unit		Fatalities	Fatalities	Fatalities	Injuries	Injuries	Injuries
	Base year		1999	1999	1999	1999	1999	1999
	Column							
1	AUSTRIA	AT	0	8	1.00	2	16	2.25
2	BELGIUM	BE	0	3	0.41	0	6	0.82
3	DENMARK	DK	2	...	...	12	...	...
4	FINLAND	FI	0	1	0.29	0	6	1.76
5	FRANCE	FR	0	12	0.18	0	24	0.36
6	GERMANY	DE	2	26	0.38	11	40	0.70
7	GREECE	GR	0	1	0.63	7	24	19.58
8	IRELAND	IE	0	0	0.00	0	0	0.00
9	ITALY	IT	0	22	0.51	6	55	1.40
10	LUXEMBOURG	LU	0	0	0.00	0	0	0.00
11	NETHERLANDS	NL	...	...	...	...	...	...
12	NORWAY	NO	0	0	0.00	0	0	0.00
13	PORTUGAL	PT	0	10	0.00	0	55	0.00
14	SPAIN	ES	0	0	0.00	0	0	0.00
15	SWEDEN	SE	0	0	0.00	0	2	0.27
16	SWITZERLAND	CH	1	3	0.32	0	6	0.48
17	UNITED KINGI	UK	29	8	0.00	126	38	0.00
	Total		**34**	**94**	**4**	**164**	**272**	**568**

Table 68 Accident data rail transport 1999. Fatalities and Injuries 1999. Source: IRTAD 2003. Remark: ...: no data available for the respective year.

Air accident data

Air accident data is taken from ICAO:

VICTIMS IN AVIATION ACCIDENTS OVER EU TERRITORY BY ANY OPERATOR	
Years	**Passenger fatalities per 100 million pkm**
1990	0.03
1991	0.03
1992	0.05
1993	0.04
1994	0.05
1995	0.02
1996	0.05
1997	0.03
1998	0.03
1999	0.02

Table 69 Source: ICAO 2001a: The World of Civil Aviation 1999-2002, ICAO, 2001

NOISE

The data base for the national population exposed to transport noise is based on the data sets, which were already used for the INFRAS/IWW (1995) and INFRAS/IWW (2000) studies. In these two studies the data was taken out of the OECD Environmental Compendium 1993 (OECD 1993), updated and extended with up-to-date national studies.

For this update-study the data sets were updated again with some new national studies (e.g. results of national studies in Austria and Italy about road-, rail- and rail-noise were accounted). In the field of rail noise the STAIRRS project (STAIRRS 2001a/b) have provided with a series of new values. The following Table 70 documents the used values. The values were compiled by assessing the literature listed in the bottom line of the table.

NATIONAL POPULATION EXPOSED TO TRANSPORT NOISE
MILLION

Country	Year	Road					Air					Rail				
		55-60	60-65	65-70	70-75	>75	55-60	60-65	65-70	70-75	>75	55-60	60-65	65-70	70-75	>75
Austria (1,2)	2002	2.34	1.82	0.42	0.29	0.08	0.02	0.02	0.00	0.00	0.00	0.10	0.05	0.04		
Belgium	00/89	3.00	2.72	1.08	0.09							0.52	0.31	0.14	0.05	0.02
Denmark	1990	0.56	0.41	0.41	0.06		0.06	0.03	0.01				0.05	0.02	0.01	
Finland (3)	00/89	0.35		0.21	0.04							0.02	0.01	0.01	0.00	0.00
France (4)	1986	12.00	9.30	6.20	2.76							0.22	0.23	0.11	0.06	
Germany (5)	2000	14.84	12.61	7.42	4.2	1.24			0.30		0.13	8.57	5.11	1.90	0.58	0.08
Greece (10)	1980	2.02	1.01	1.01	0.81	0.20										
Ireland	2000											0.03	0.02	0.01	0.00	0.00
Italy (7)	1997	19.00	12.47	7.23	2.18	0.59	1.47	1.06	0.47	0.18	0.19	3.59	2.59	1.35	0.42	0.18
Luxemb'g	2000											0.02	0.01	0.01	0.00	0.00
Netherl.	1987	5.10	2.40	0.40	0.15	0.15	3.15	1.80	0.30	0.10		0.67	0.14	0.04	0.03	0.02
Norway (1)	1991	0.60	0.40	0.25	0.08	0.03	0.01	0.07	0.02	0.01	0.01	0.02	0.00	0.01	0.00	0.00
Portugal	00/90			0.74		0.06			0.04		0.01	0.36	0.21	0.10	0.04	0.02
Spain	00/80	7.35	4.83	2.80	0.84	0.24						0.49	0.30	0.14	0.05	0.02
Sweden (6)	1991	0.84	0.40	0.27	0.06		0.07	0.04	0.00	0.00		0.24	0.13	0.05	0.01	
Switzerl. (8)	02/85	1.98	1.05	0.55	0.24	0.06	0.02	0.03	0.05	0.01	0.00	0.48	0.22	0.11	0.05	0.01
UK (1)	90/89/72	16.20	10.20	4.60	0.50	0.60		1.21	0.16	0.03			0.50	0.16	0.04	

Table 70 National population exposed to transport noise [Million], OECD 1993. Additional sources:
(1) from questionnaire
(2) Federal Environmental Agency Austria, 2001
(3) Ekono Energy, 1993
(4) UIC – Internalisation of external effects
(5) UBA, 2000 (projected to total Germany)
(6) Hansson, 1994
(7) Schade 2003, Ministero dell'Ambiente 1997
(8) BUWAL, 2002
(9) STAIRRS, 2001 (italic letters)
(10) OECD/ECMT Transport and the Environment 1998

According to the INFRAS/IWW (1995) and INFRAS/IWW (2000) studies it is still a problem to get empirical data for all countries, transport modes and noise exposure levels. Thus, missing data had to be estimated using techniques of data extrapolation.

The results of the data compilation are shown in Table 71. It should be kept in mind that some of the data sets must be handled with care for lack of better data.

NATIONAL POPULATION EXPOSED TO TRANSPORT NOISE
MILLION

Country	Year	Road					Air					Rail				
		55-60	60-65	65-70	70-75	>75	55-60	60-65	65-70	70-75	>75	55-60	60-65	65-70	70-75	>75
Austria	2002	2.34	1.82	0.42	0.29	0.08	0.02	0.02	0.00	0.00	0.00	0.10	0.05	0.04	0.03	0.02
Belgium	89/00	3.00	2.72	1.08	0.09	0.01	0.12	0.09	0.04	0.02	0.01	0.52	0.31	0.14	0.05	0.02
Denmark	1990	0.56	0.41	0.41	0.06	0.04	0.06	0.03	0.01	0.01	0.00	0.08	0.05	0.02	0.01	0.00
Finland	89/00	0.35	0.24	0.21	0.04	0.00	0.06	0.04	0.02	0.01	0.01	0.02	0.01	0.01	0.00	0.00
France[3]	1986	12.0	9.30	6.20	2.76	0.34	0.69	0.49	0.20	0.09	0.06	0.22	0.23	0.11	0.06	0.05
Germany[4]	2000	14.8	12.6	7.42	4.2	1.24	0.47	0.39	0.30	0.20	0.13	8.57	5.11	1.90	0.58	0.08
Greece	1980	2.02	1.01	1.01	0.81	0.20	0.05	0.05	0.02	0.01	0.01	0.08	0.04	0.01	0.01	0.00
Ireland	2000	0.69	0.45	0.26	0.08	0.02	0.04	0.03	0.01	0.01	0.00	0.03	0.02	0.01	0.00	0.00
Italy	1997	18.4	12.1	7.01	2.11	0.57	1.47	1.06	0.47	0.18	0.19	3.59	2.59	1.35	0.42	0.18
Luxemb'g	2000	0.08	0.05	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.01	0.00	0.00
Netherl.	1987	5.10	2.40	0.40	0.15	0.15	3.15	1.80	0.30	0.10	0.05	0.67	0.14	0.04	0.03	0.02
Norway	1991	0.60	0.40	0.25	0.08	0.03	0.01	0.07	0.02	0.01	0.01	0.02	0.00	0.01	0.00	0.00
Portugal	90/00	1.94	1.28	0.74	0.22	0.06	0.12	0.09	0.04	0.02	0.01	0.36	0.21	0.10	0.04	0.02
Spain	80/00	7.35	4.83	2.80	0.84	0.24	0.46	0.33	0.14	0.06	0.04	0.49	0.30	0.14	0.05	0.02
Sweden	1991	0.84	0.40	0.27	0.06	0.01	0.07	0.04	0.00	0.00	0.00	0.24	0.13	0.05	0.01	0.00
Switzerl.	85/02	1.98	1.05	0.55	0.24	0.06	0.02	0.03	0.05	0.01	0.00	0.48	0.22	0.11	0.05	0.01
UK[1]	90/89/72	16.2	10.2	4.60	0.50	0.60	2.25	1.21	0.16	0.03	0.01	0.66	0.50	0.16	0.04	0.02

Table 71 Estimation of population exposed to transport noise [Mill.].
Remarks:
- Figures in **bold letters** are based on the mean values
- Figures in **italic letters** are estimated
- Figures, marked with grey are "updated"

Data about the population exposed to air traffic noise is still not very reliable. To get more precise information, detailed reports on exposed inhabitants for a sample of European airports were accounted.

A more precisely look on the values of the exposed population in comparison between different countries (e.g. The Netherlands, Switzerland and Germany) shows that the ratio between the Rail/ Road and Air exposed population differentiate from country to country. The Netherlands with the highest population density report for 1998 about less than two third of noise annoyance compared with Germany and Switzerland (cp. [Schade 2003]). This is shown in Table 72. This could partially be due to differences in the surveys, but also due to the different noise abatement policies in the different countries (e.g. very early the Netherlands noise abatement act in 1979 introduced a general nation-wide noise exposure target of 50 dB(A)).

COMPARISON OF SHARES OF PERSONS REPORTING ANNOYANCE BECAUSE OF TRANSPORT NOISE IN SURVEYS			
	Netherlands	**Germany**	**Switzerland**
Share of annoyed persons in surveys 1998 [%]	40 all sources	58,5 only transport sources	64 all sources
Average population density [pers/km²]	379	230	177

Table 72 Comparison of shares of persons reporting annoyance because of transport noise in surveys (cp. [Schade 2003]).

INFRASTRUCTURE

Infrastructure data for all modes are needed to determine infrastructure area and total costs for nature and landscape. The first step to calculate infrastructure area for road, train and inland waterborne transport is the length of this transportation routes resp. the number of airports in every country.

Road infrastructure

2000					
Country	Shortcut	Motorways	Highways, main or national roads	Secondary or regional roads	Other roads
Unit		km	km	km	km
Base year		2000	2000	2000	2000
AUSTRIA	AT	1'634	10'260	23'065	98'000
BELGIUM	BE	1'691	12'542	1'326	130'300
DENMARK	DK	902	758	9'961	59'882
FINLAND	FI	512	13'271	28'633	35'993
FRANCE	FR	9'626	27'500	358'500	586'000
GERMANY	DE	11'515	41'321	86'823	502'253
GREECE	GR	700	9'100	31'300	75'600
IRELAND	IE	103	5'270	10'700	76'600
ITALY	IT	6478	46'043	113'924	487'752
LUXEMBOURG	LU	115	837	1'911	2'326
NETHERLANDS	NL	2'291	6'650	57'500	59'400
NORWAY	NO	144	26'561	27'213	36'962
PORTUGAL	PT	1'441	11'408	58'990	n.a.
SPAIN	ES	8'893	24'124	139'656	489'698
SWEDEN	SE	1484	13212	83427	112829
SWITZERLAND	CH	1642	18276	51197	n.a.
UNITED KINGDOM	UK	3529	48194	113105	207256
TOTAL	TT	52'700	315327	1197231	2960851

Source: EC 2002: EU Energy and Transport in Figures 2002

Note : > The definition of road types varies from Country to Country
> The figure for "Other roads" in Germany derives from 1995

Table 73 Road network in EU17 countries.

Rail infrastructure

2000		Lines not electrified			Electrified lines			Total
Country	Shortcut	Total	single track	douple track or more	Total	single track	douple track or more	
Unit Base year		km	km	km	km	km	km	km
AUSTRIA	AT	2'309	2'292	17	3'356	1'505	1'851	5'665
BELGIUM	BE	766	495	271	2'705	347	2'358	3'471
DENMARK	DK	1'422	1'048	374	625	92	533	2'047
FINLAND	FI	3'482	3'482	0	2'372	1'865	507	5'854
FRANCE	FR	15'177	3'620	11'557	14'166	1'885	12'281	29'343
GERMANY	DE	17'573	14'861	2'712	19'079	4'050	15'030	36'652
GREECE	GR	2'299	1'978	321	0	0	0	2'299
IRELAND	IE	1'872	1'419	453	47	0	47	1'919
ITALY	IT	5'537	5'493	44	10'946	4'826	6'120	16'468
LUXEMBOURG	LU	13	13	0	261	121	140	274
NETHERLANDS	NL	740	0	740	2'062	286	1'776	2'802
NORWAY	NO	1'660	1'660	0	2'519	2'334	185	4'179
PORTUGAL	PT	1'910	1'876	34	904	440	464	2'814
SPAIN	ES	6'343	6'322	21	7'525	4'015	3'510	13'868
SWEDEN	SE	2'541	2'541	0	7'405	5'710	1'695	9'946
SWITZERLAND	CH	19	19	0	4'989	2'879	2'111	2'975
UNITED KINGDOM	UK	11'418	4'304	7'114	4'988	3'140	1'848	16'406
TOTAL	TT	75'081	51'423	23'658	83'950	33'494	50'455	156'983

Data source
1) UIC 2000: Statistique Internationale des Chemins de fer 2000
2) UIC 2001: Statistique Internationale des Chemins de fer 2001
3) Data for Switzerland: Schweizerische Verkehrsstatistik 1996/2000, BfS, Neuenburg 2000

Table 74 Rail network in EU17 countries.

Aviation and waterborne transport infrastructure

		Number of Airports			Canals
Country Unit	Shortcut	National Airports N°	Regional Airports N°		Network Length km
Base year		1995	1995		1997
AUSTRIA	AT	3	6		-
BELGIUM	BE	5	6		880
DENMARK	DK	2	15		-
FINLAND	FI	6	23		125
FRANCE	FR	15	122		4'183
GERMANY	DE	25	90		1'729
GREECE	GR	2	46		6
IRELAND	IE	3	17		-
ITALY	IT	7	67		203
LUXEMBOURG	LU	1	0		-
NETHERLANDS	NL	8	18		3'745
NORWAY	NO	1	57		n.a.
PORTUGAL	PT	3	21		-
SPAIN	ES	10	46		-
SWEDEN	SE	11	45		70
SWITZERLAND	CH	2	18		-
UNITED KINGDOM	UK	20	134		191
TOTAL	**TT**	**124**	**731**		**11'132**

Source: Airport data: INFRAS/IWW 2000
Inland waterways: EC 2001 (EU Energy and Transport in Figures 2001)

Table 75 Length of canals (not included are river and lakes) and the number of national and regional airports in EU17 countries.

CONGESTION

Additional Input Data

The methodology for estimating urban congestion costs requires the following input data:

1. A representative speed-flow relationship for a typical urban arterial and an ordinary secondary road taken out of the German EWS manual.
2. Travel speeds in peak and off-peak in selected urban areas from UNITE (Accounts and case studies).
3. The price elasticity of demand of urban travel, if available for peak and off-peak traffic.

4. Total travel demand and traffic mix per country on urban arterials and other urban roads, each for peak and off-peak traffic.

As in the previous study we select the speed-flow relationships from the German EWS manual. from the 24 road types provided by the manual we select an ordinary main road with a single carriageway and two lanes per direction (Type 5.21). For this road type the speed flow function takes the form:

$$V = 60.1 - 0.1 \cdot \exp(2.536 \cdot 10^{-3} \cdot Q)$$

V is the travel speed of passenger cars and goods vehicles in kph and Q denotes the traffic volume in PCE/h. Beyond a certain traffic volume, which corresponds to a travel speed of approximately 40 kph on road type 4.21 and 20 kph for road type 5.12) the function would be replaced by another one, which would smoothly approach a positive, minimum travel speed. As this would violate the idea of marginal cost pricing and the computation of the deadweight loss, we use the simple form as presented above.

The share of congested Traffic and the travel speeds in congestion and in normal traffic conditions are taken out of the country reports of the UNITE projects (D5, D8 and D12).

Country	**Share of congested traffic**	**Congestion**		**Normal conditions**	
		Arterial	Other	Arterial	Other
Germany	1.5 %	5.3 [1]		35.2	18,6
Switzerland		30.9		36.0	
Austria	1.9 %	10	10	58	19
Spain	0.4 %	10 [2]		90 [2]	
Netherlands	1.5 %	10		27.13	
Greece		13		30	
Italy		18.4		25	
Portugal	1.4 %	10		40	

[1] Stop-and-go speed. - [2] All roads besides motorways

Table 76 Travel speeds and share of congested traffic in urban areas (source: UNITE)

In particular the travel speeds for Switzerland are outstanding as here the classification of traffic conditions was peak / off-peak and not congestion / normal conditions. Another extreme is provided by the German values because congestion here is defined strictly as stop-and-go traffic. As the remaining values tend to converge at 10 kph for congested conditions and around 30 kph for normal traffic conditions we select these two values as representative for all European cities.

This approach of distinguishing between congested and non-congested conditions is more direct then the one taken by the previous study, in which it was distinguished between peak and off-peak conditions, for which (widely differing) speed data was taken for a number of sample cities worldwide.

The data shows that there is very limited information on the details of urban traffic condition on a European scale available and that the typology of traffic situation widely diverges, even within the UNITE project. Thus, for this study we take an averaging European perspective by making the following assumptions:

1. Travel speeds under congestion are 10 kph and 30 kph otherwise.
2. The share of congested traffic relative to total urban traffic is 1.5%.
3. The share of urban traffic is provided by the TRENDS database for the EU countries. The missing values are set in accordance with Austria (representative for Switzerland), Sweden and Finland (representative for Norway).

According to the previous study, the price elasticity of traffic demand is set to -0.3 for urban as well as for inter-urban traffic.

For calculating national values of travel time in urban areas the share of travel purposes (business, private/commuting and leisure) and the vehicle occupancy rates have been extracted from the UNITE country accounts data. Unfortunately, most countries have either not reported this information, have simply used the data proposed for Germany or have not distinguished between rural and urban roads. The data available is presented in Table 77.

	Business	Private/ commuting	Leisure	Business	Private/ commuting	Leisure
Urban roads						
Austria	12%	64%	24%	1.1	1.3	2.0
Germany	18%	34%	48%	1.2	1.4	2.1
Greece	39%	39%	22%	1.2	1.4	2.0
Portugal	9%	74%	17%	1.2	1.2	1.6
Spain	18%	33%	49%	1.2	1.4	2.1
Switzerland	15%	65%	20%	1.3	1.2	2.0
This Study	12%	64%	24%	1.1	1.3	2.0
Inter-urban roads						
Germany	18%	34%	48%	1.2	1.4	2.1
Greece	20%	50%	30%	1.2	1.4	2.0
Spain	18%	33%	49%	1.2	1.4	2.1
Switzerland	20%	33%	47%	1.3	1.2	2.0
This study	18%	34%	48%	1.2	1.4	2.1

Table 77 Share of travel purposes and vehicle occupancy rates in car travel (source: UNITE)

Most of the UNITE countries either use the default data provided for Germany (which does not distinguish between urban and non-urban traffic) or do not report the contents of their sources. Further, the available data on travel purposes in urban traffic show some contradicting tendencies: While Greece reports a much higher share of business traffic in agglomerations, Portugal, Austria and Switzerland report vice-versa figures. Thus, for urban areas we use the Austrian data as this averages between the available specific urban values. For inter-urban traffic we select the German data, as this is used by most of the UNITE country accounts.

The picture concerning vehicle occupancy rates looks more condensed. Here we also chose the German values for inter-urban traffic and reduce them by 0.1 for all travel purposes in the case of urban traffic.

Value of Time and unit cost functions

Both, urban and inter-urban congestion is computed by speed-flow functions, which express travel speed as a function of the passenger car equivalents (PCE) per hour. Thus, the Value of Time used in this study must be expressed in Euro/PCE-h. Using the above data on travel purposes and their valuation according to the UNITE valuation conventions, average European values of time per vehicle-h is calculated according to Table .

Vehicle type	Passenger car			Bus/coach	2-Wheelers	LDV	HDV
Units	Business	Private/ commutng	Leisure	private/commuting and leisure		All commodities / average velhicle load	
Urban roads							
- Occupancy	1,20	1,40	2,10	30,00	1,10	1,00	1,00
- VOT / unit	21,00	6,00	3,50	5,32	5,32	40,76	43,47
- Share of purpose	0,12	0,64	0,24	-	-	-	-
- VOT / veh.	25,20	8,40	7,35				
(all purposes)			10,72	159,55	5,85	40,76	43,47
- PCE			1,00	2,50	0,50	1,52	2,50
Inter-Urban roads							
- Occupancy	1,20	1,40	2,10	30,00	1,10	1,00	1,00
- VOT / unit	21,00	6,00	4,00	4,83	4,83	40,76	43,47
- Share of purpose	0,18	0,34	0,48	-	-	-	-
- VOT / veh.	25,20	8,40	8,40				
(all purposes)			12,46	144,88	5,31	40,76	43,47
- PCE			1,00	2,50	0,50	1,52	3,50

Table Vehicle-specific parameters for calculating congestion costs

This average European Value of Time is converted into national values per passenger car equivalent in urban and inter-urban travel using the country-specific traffic mix of each network category out of Table 46. The resulting values of travel time are presented in Figure 25.

VALUES OF TIME PER PASSENGER CAR EQUIVALENT

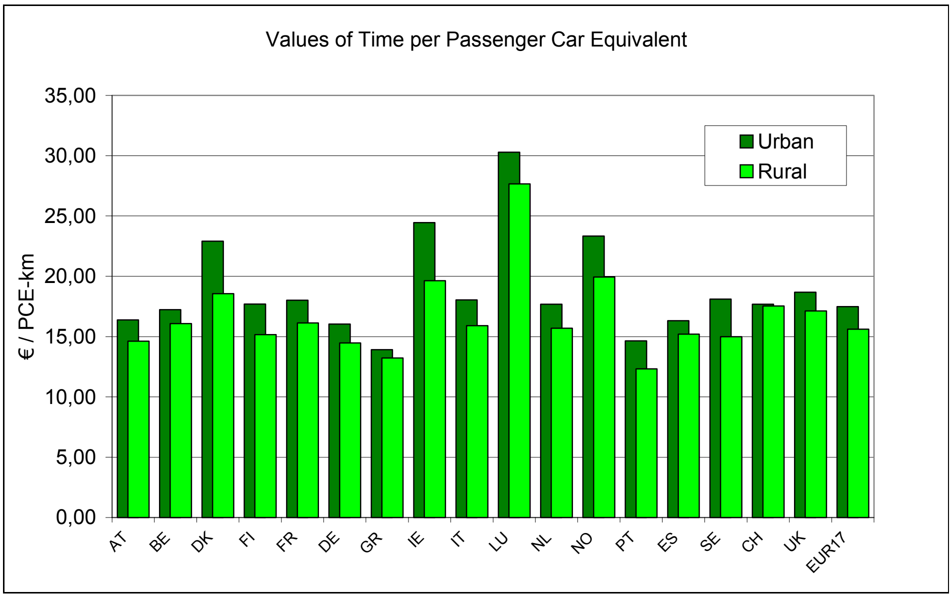

Figure 25 Comparison of national Values of Time.

Unit cost functions express the average costs per passenger car equivalent by traffic situation, which are LOS A to F in inter-urban traffic and congestion / normal conditions in urban transport. According to the type of output, unit costs are computed as follows:

- Concerning the total revenues to be expected from road pricing the unit costs are calculated deriving the product out of the number of users times the derivative of the users' average travel time by the number of users.
- For calculating the deadweight loss, the difference between the marginal external cost curve and the demand curve is computed.
- For the delay cost measure, the extra travel time per km compared to a reference service level, which is selected to be LOS-B for all road categories, is computed.

Road type	Value	Unit costs (h / 1000 PCE-km) A	B	C	D	E	F
Motorways	DWL	0.20	0.79	2.36	5.33	7.19	10.60
	REV	2.33	10.10	58.36	82.66	82.66	82.66
	Delay	0.00	0.00	0.28	35.40	36.83	37.36
Trunk roads	DWL	0.22	0.82	1.34	2.08	2.23	2.60
	REV	2.74	13.50	43.87	45.87	45.87	45.87
	Delay	0.00	0.00	0.57	78.90	84.17	84.17
Urban roads	DWL	3.27	4.46	7.04	13.06	19.79	34.28
	REV	53.57	77.54	127.90	226.42	226.42	226.42
	Delay	0.00	0.00	8.20	50.75	63.73	65.34

Table 78 Average European value of travel time by vehicle type.

Service levels in road transport

The input data for estimating road congestion costs is provided by the base scenario 2000 of the TEN-STAC project carried out for the European Commission. The modelled traffic flows are calibrated by automatic counting post information. For the current analysis transport flows by passenger cars and by goods vehicles on motorways and on trunk roads are distinguished. The model results for buses are not used by road segment as they do not match the counting post data sufficiently.

Using the EWS speed flow curves and the Level-of-Service definition by the HBS manual as described in Section 2.7 the model data can be compiled into vehicle kilometres by service level. The aggregated data by country is presented in Table 79 and Table 80.

TRANSPORT VOLUME ON MOTORWAYS BY TRANSPORT TYPE AND LOS MILLION PCE-KM						
Country	**Level of Service**					
	A	**B**	**C**	**D**	**E**	**F**
AUSTRIA	20.260	4.965	2.258	1.346	1.080	1.071
BELGIUM	13.942	6.576	4.482	3.687	1.528	4.137
DENMARK	10.754	2.883	1.018	778	220	280
FINLAND	20.326	1.608	524	125	14	14
FRANCE	99.150	35.171	21.576	12.523	7.675	11.375
GERMANY	117.582	35.650	31.729	26.258	16.411	35.547
GREECE	10.901	483	247	167	122	1.627
IRELAND	7.683	1.142	511	159	0	3
ITALY	63.295	23.529	14.306	11.022	5.166	11.780
LUXEMBOURG	776	133	193	37	61	0
NETHERLANDS	16.461	5.550	4.856	4.184	3.045	15.503
NORWAY	7.446	580	337	182	154	483
PORTUGAL	10.026	2.847	1.373	1.161	98	617
SPAIN	30.589	6.208	3.110	1.784	639	1.550
SWEDEN	30.305	3.197	1.424	308	298	415
SWITZERLAND	14.390	2.829	1.597	1.354	408	1.317
UNITED KINGDOM	40.041	10.727	8.480	7.098	3.852	30.384
TOTAL	513.926	144.078	98.022	72.176	40.770	116.104

Table 79 PCE-km by LOS on motorways 2000

For other inter-urban roads than motorways (trunk roads) the traffic volume data reported by the VACLAV traffic model had to be updated as the model does not contain all national road links. Thus, the difference between the total national volumes reported by the TRENDS database and the VACLAV database had been allocated to trunk roads. As it can be assumed that the most important links are contained in the VACLAV model, the remaining vehicle kilometres are allocated to LOS-level A (compare Table 80).

TRANSPORT VOLUME ON TRUNK ROADS BY TRANSPORT TYPE AND LOS
MILLION PCE-KM

Country	Level of Service					
	A	B	C	D	E	F
AUSTRIA	46.486	146	53	9	24	18
BELGIUM	50.635	875	297	220	147	504
DENMARK	18.637	0	0	0	0	0
FINLAND	21.111	0	0	0	0	0
FRANCE	120.430	8.067	4.788	2.844	1.759	3.056
GERMANY	276.842	1.825	874	621	475	1.509
GREECE	39.963	184	0	0	0	771
IRELAND	14.544	179	28	28	80	60
ITALY	263.517	1.656	90	93	0	0
LUXEMBOURG	1.796	0	0	0	0	0
NETHERLANDS	18.293	586	431	385	233	710
NORWAY	15.255	84	100	106	0	79
PORTUGAL	49.270	175	31	45	0	495
SPAIN	179.076	11.458	4.831	3.073	1.444	1.908
SWEDEN	28.402	107	0	0	0	0
SWITZERLAND	21.585	7	5	0	0	0
UNITED KINGDOM	159.061	7.946	4.955	3.375	1.060	5.634
TOTAL	1.324.904	33.297	16.483	10.800	5.223	14.746

Table 80 PCE-km by LOS on trunk roads 2000

The traffic conditions on urban roads are only differentiated by "normal traffic conditions" (LOS-level B) and "congested traffic conditions" (LOS-level E). According to the reports of the UNITE project on the share of congested traffic in a number of urban areas (Vienna, Lisbon, Oporto, Athens) a common share of 1.5% is used.

Results

Table 81 presents the results for the three measures of congestion costs by country. We can draw the following conclusions:

› The deadweight loss as the economic measure of total congestion costs, is roughly twice as high (63 billion Euro) as the figure presented in the 2000 study (33 billion Euro). The reason for this drastic increase is a methodological one, as (1) the networks of the VACLAV traffic model are more dense than the ones used in the 2000 study and (2) traffic volumes, which are not considered by the VACLAV model, had been included here. Respectively, the overall increase in the vehicle kilometres captured by the present methodology is also roughly twice as high as the traffic volumes considered it the 1995 study.

- The revenues to be expected from short-run marginal congestion pricing is more than ten times higher than the social surplus created under this pricing regime, which is the deadweight loss. Thus, it is most likely that the welfare gains from applying social marginal cost pricing are eaten up by transaction costs for running the pricing system and for collecting and allocating the revenues.
- Even under the cautious assumptions taken here, the delay cost measure is between six and seven times higher than the deadweight loss. Considering the previous statements on the possible inefficiency of raising congestion charges, this measure thus may lead to wrong policy conclusions.

RESULTS OF THE CONGESTION COST MEASURES
MILLION EURO PER YEAR

Country	Deadweight loss			SRMC-Pricing Revenues			Delay costs		
	Inter-urb.	Urban	Total	Inter-urb.	Urban	Total	Inter-urb.	Urban	Total
AUSTRIA	730	494	1'224	9'532	5'729	15'261	1'935	2'315	4'250
BELGIUM	1'724	462	2'186	21'505	5'348	26'853	6'676	2'226	8'901
DENMARK	363	452	814	5'015	5'223	10'238	861	2'176	3'037
FINLAND	182	280	462	2'496	3'231	5'727	85	1'386	1'472
FRANCE	6'418	3'081	9'500	88'016	35'606	123'622	28'874	14'999	43'873
GERMANY	12'008	4'345	16'354	143'138	50'323	193'461	44'683	20'700	65'383
GREECE	435	495	931	4'633	5'727	10'360	1'801	2'398	4'199
IRELAND	162	175	337	2'431	2'030	4'461	392	836	1'228
ITALY	5'474	2'545	8'019	68'118	29'422	97'539	16'410	12'341	28'752
LUXEMBOURG	48	62	110	760	713	1'473	100	298	399
NETHERLANDS	3'700	562	4'263	37'583	6'528	44'111	14'925	2'610	17'534
NORWAY	276	192	468	3'317	2'207	5'524	904	957	1'862
PORTUGAL	408	258	666	5'557	2'994	8'550	1'398	1'194	2'592
SPAIN	1'793	2'087	3'880	27'297	24'129	51'425	10'231	10'095	20'325
SWEDEN	395	367	761	5'241	4'231	9'472	567	1'805	2'372
SWITZERLAND	660	276	936	8'226	3'177	11'403	1'974	1'374	3'349
UNITED KINGDOM	8'486	3'623	12'108	91'374	41'825	133'199	40'478	17'763	58'241
TOTAL	43'263	19'755	63'018	524'238	228'442	752'680	172'295	95'472	267'767

Table 81 Measures of road congestion 2000.

ANNEX 2: MEMBERS OF THE ADVISORY BOARD

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Wim OOSTERWIJK, NS - NV
Stephen PERKINS, ECMT
Britta SCHREINER, CER
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Sabine VAN SIMAEY, SNCB/NMBS
Peter WIEDERKEHR, OECD

GLOSSARY

Accident insurance	Voluntary or mandated insurance against the risks of accidents (property and health). The premia serve to (partly) internalise external costs.
Accident rate	Accident rates describe the probability of an accident per 1'000 vehicle kilometres.
Average costs	Total costs in a period, divided by the quantity (out-put) produced/consumed in that period. Long term average costs include a share of fixed costs (e.g. costs associated with expansion of existing infra-structure).
Barrier effect	Separation of adjacent areas due to road or rail infrastructure investments; negative impact on human beings (e.g. recreation), or on flora and fauna (e.g. constriction of habitat).
Contingent valuation method	Valuation technique which asks people directly how much they are willing to pay/to accept for improving/deteriorating environmental quality. Method is based on the stated preference approach; it is the only method that allows the estimation of existence value. The values obtained are compared with other opportunities, in order to make visible a budget restriction.
Cost-effectiveness	Seeks to minimise the costs of achieving a given (e.g. environmental) objective/target. This principle is a "second-best" efficiency criterion, often used when a full cost-benefit analysis is not feasible.
CO_2	Carbon dioxide is a major greenhouse gas i.e. it contributes to the climate change.
Decibel	(dB(A)) Decibel (dB) is a measure for the intensity of sound energy. According to the characteristic of human ears the relationship between sound energy and dB is logarithmic. Several filters have been defined to achieve a better adaptation of dB measurements and the loudness impression of human beings. The most commonly used type of filter is the (A) filter.
Defensive expenditures	Valuation technique wherein a value for environmental quality is inferred from people's (voluntary) expenditures aimed at improving their situation.

Dose-response-functions	Functions showing the connection between a specific concentration and its specific effects. They are especially used for the measurements of air pollution impacts. For example health: Impacts on mortality due to specific air pollution concentrations.
Efficiency	Refers to the efficient allocation of scarce resources. At the margin, resources should be used by the individual who is willing to pay the most for them (i.e. where marginal social cost equals marginal social benefit).
Elasticity	Proportional change in demand in response to a price increase or decrease (price elasticity); or reaction in total demand after an increase/decrease in income (income elasticity).
Environmental effectiveness	Effect on the environment that a given policy response generates. This criterion ignores the economic costs that may result from implementing the policy.
Existence value	Economic value which people attribute to something purely for its existence (no consumption is fore-seen); can only be estimated via the contingent valuation method.
Externality (external cost)	Economic cost not normally taken into account in markets and in the decisions made by market players.
Fixed cost	Cost which are not depending on the traffic volume (in the short run).
(Full) fuel cycle	Complete fuel cycle; comprising discovery, depletion (mining), processing, transport and use of an energy resource.
Free-flow situation	Traffic situation without congestion, used as a reference level. Usually an Off-Peak-Situation can be used for urban traffic.
GDP	(= Gross Domestic Product). The GDP is the sum of all goods and services produced within a country and a year. GDP per capita can be regarded as the relative economic power of a country per inhabitant.
HC/VOC	Hydrocarbons / Volatile Organic Compounds contribute to ozone formation. Some like benzene, butadiene and benzo-a-pyrene have been found to have impacts on public health.
HDV	Heavy duty vehicles (Road trucks) above 3,5 tonne gross weight.

Hedonic pricing	Valuation technique which infers a value for environmental quality from rent or property price differentials.
Human value (loss)	Value attributed to human life in excess of the average economic output produced by an individual (e.g. grief, pain, etc.). –> VSL
Internalisation	Incorporation of an externality into the market decision making process through pricing or regulatory intervention. In the narrow sense internalisation is implemented by charging the polluters with the damage costs of the pollution generated by them, the corresponding damage costs resp. according to the polluter pays principle.
LDV	Light duty vehicles (Vans up to 3,5 tonnes gross weight).
Life-cycle based approach	An approach, where up- and downstream processes of transport services are included (i.e. vehicle production and disposal, fuel cycles of the electricity production etc.).
Marginal costs	Costs related to a small increment in demand (e.g. an extra vehicle-kilometre driven). Long-term marginal costs include the capacity expansion needed to service increased traffic demands.
MC	Motorcycle
NOx	Nitrogen oxides, which are formed primarily by fuel combustion and contribute to the formation of acid rain. They also combine with hydrocarbons in the presence of sunlight to form ozone.
Opportunity costs	Costs which arise when a particular project restricts alternative uses of a scarce resource (e.g. land-use of infrastructure prevents an alternative use, such as recreation). The size of an opportunity cost is the value of a resource in its most productive alternative use.
Option value	Value of keeping open the possibility of consuming a good/service at some time in the future.
PCU	(= Passenger Car Units) PCU is used in order to standardise vehicles in relation to a passenger car. Speed and lengths differentials are most common. Within this study they are used for the allocation of different costs (e.g. nature and landscape, urban effects, congestion).
pkm	Passenger kilometre

PM	Particulate matter. Fine particulate (PM10 with a diameter of less than 10 m) can contribute to the chronic and acute respiratory disease and premature mortality, as they are small enough to be inhaled into the lungs. Larger particles decrease visibility and increase fouling.
Polluter-pays-principle	Political/economic principle which stipulates that the user should pay the full social cost (including environmental costs) of his/her activity.
Precombustion	Production, storage and transportation of energy for its final use.
Prevention approach	Valuation technique for estimating externalities whereby the costs of preventing damage are used as a proxy for the cost of the damage itself for society.
Productivity	Output divided by the inputs needed to produce that output in value terms.
Public good	Good/service for which property rights are not defined. Without government intervention, environmental goods (e.g. clean air) are usually treated as public.
Progressivity/Regressivity	Term to describe the impact of government policy on income distributions. Progressive/regressive effects occur when poor households spend a smaller/larger proportion of their income for a particular measure (e.g. a tax) than do richer households.
Purchasing power parity (= PPP)	The purchasing power parity describes the amount of goods or services which can be bought in a particular country compared to a reference country. The PPP necessarily must be expressed relative to a particular currency.
Revealed preference	Valuation technique wherein consumers. choices are revealed in the marketplace (e.g. by the purchase of a good).
Risk approach	Valuation technique for estimating externalities whereby external costs inferred from premia for risk factors (e.g. the cost of insurance, or of risk diversification).
Risk value	Monetary value for pain, grief and suffering of an average transport victim, mainly used for the estimation of accident fatalities.

Shadow Prices	Shadow price is the marginal opportunity cost of the use of a resource (i.e. the loss of benefits caused if this resource cannot be used the next best purpose).
Social costs	The sum total of internal and external costs.
Social cost benefit analysis	Systematic estimation of all costs and benefits of a project that are relevant to society. Includes both technological externalities and pecuniary externalities, as long as the latter are not merely redistribution of income.
SO2	Sulphur dioxide contributes to the formation of sulphate aerosols and is the primary pollutant in the formation of acid rain. It can also cause respiratory system damage in humans.
Speed-flow function	A mathematical or graphical relationship between the flow on a particular road, and the speed of that traffic flow. As traffic flows increase, traffic speeds eventually fall.
Stated preference	Valuation technique wherein monetary estimates are derived from hypothetical statements by individuals about their preferences. The typical method used is a questionnaire approach (e.g. contingent valuation method).
Technological Externality	External effect that is not actively or voluntarily processed through markets, which results in economic inefficiencies. This occurs when some firm or individual uses an asset without paying for it. Technically they occur where one productive activity changes the amount of output or welfare which can be produced by some other activity using any given amount of resources. Negative technological externalities reduce the amount of output or welfare which an economy can produce with any given allocation of inputs.
tkm	Tonne kilometre
Traffic mode	Category of means of transport (road, rail, aviation, shipping, etc.).
Traffic volume	Measure for traffic activity which can be expressed in vehicle-kilometres, or in passenger/tonne kilometres.
UCPTE	(Union pour la coordination de la production et du transport de l'éléctricité)

International mix of electricity production, varying slightly every year. The mix used for the forecast 2010 is based on:

	50% fossil fuels 15% hydro generation 35% nuclear generation.
Unit costs	Costs per unit of service or goods provided (e.g. traffic volume).
(User) charge	Charge imposed on the user of a good (e.g. road infrastructure), often linked to the costs generated by his or her use.
Utility (Private)	Private benefit received by an individual due to his/her consumption of a good or service, or by the existence of that good/service.
Utility (Social)	The aggregate of private utilities in an economy.
Valuation	Process of estimating the economic value of a certain quantity of a transport good/service; generally expressed in monetary terms.
Value of statistical life	(=VSL) The value of statistical life is a methodology to find a monetary pendant to a killed or injured human being. VSL is the opportunity costs of a saved human life.
Variable costs	(Fixed costs) Full costs can be subdivided into fixed costs and variable costs. Fixed costs remain constant with varying use of a transport system (e.g. supplier- or capital costs for road and rail networks or administrative costs). The expression "fixed" in the way it is used in the Real Cost Scheme means "fixed in the short run" (without consideration of new infrastructure), as in the long run also infrastructure supply costs vary with the traffic demand that is in the long run all costs can be made variable. Main relations of variable costs are kilometres driven or the amount of vehicles (e.g. crossing a specific section).
Vkm, Vehicle-kilometre	One kilometre travelled by a single vehicle.
Willingness to pay	(= WTP). The willingness (or ability) of people to pay for the abolishment, reduction or reception of a particular matter can be estimated by two ways: (1) by stated preference surveys and by hedonic pricing methods.

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