COMPETITIVE AND SUSTAINABLE GROWTH (GROWTH) PROGRAMME

UNITE

UNIfication of accounts and marginal costs for Transport Efficiency

Deliverable 5, Appendix 2: The Pilot Accounts for Switzerland

Version 2.0
28 January 2002

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Abbreviations

ASTRA	Bundesamt für Strassen (Swiss Federal Roads Office)
BAZL	Bundesamt für Zivilluftfahrt (Swiss Federal Office for Civil Aviation, FOCA)
BFS	Bundesamt für Statistik (Swiss Federal Statistical Office)
BUWAL	Bundesamt für Umwelt, Wald und Landschaft (Swiss Federal Office for Environment, Forests and Landscape)
DB	Deutsche Bahn AG
EMPA	Eidgenössische Materialprüfungszentrale
GDP	Gross domestic product
GVF	Dienst für Gesamtverkehrsfragen (Service for Transport Studies)
ha	Hectare
HBEFA	Handbook of Emission Factors in Road Transport
HGV	Heavy goods vehicles
KTU	Konzessionierte Transport Unternehmen (Concessionary Transport Companies)
kWh	Kilowatt hour
LGV	Light goods vehicles
MTOW	Maximum take-off weight
NSDI	(Noise Sensitivity Depreciation Index
ÖBB	Österreichische Bundesbahnen
pkm	Person-kilometre
PPP	Purchasing power parity
PT	Public transport
RBS	Regional bus services
SBB	Schweizerische Bundesbahnen (Swiss Federal Railways)
TCS	Touring Club Switzerland
tkm	Tonne-kilometre
UIC	International Union of Railways
UPT	Urban public transport
VAT	Value added tax
VBZ	Verkehrsbetriebe Zürich
vkm	Vehicle-kilometre
VOSL	Value of statistical life
VOT	Value of time
WTP	Willingness-to-pay

1 Introduction

1.1 Study Context and Objectives

This Appendix report contains the full version of the pilot accounts developed within the UNITE project for Switzerland. It serves as background report for the results presented in the core body of deliverable 5 (Summary Report of D5 containing the pilot accounts for Germany and Switzerland) and gives more detailed descriptions on the methodology used and the input data and their reliability and quality. However, the general and detailed discussion of the accounts approach has been presented in Link et al. (2000) and will only be summarised in this document. The Appendix Report discusses methodologies only in so far as they are necessary background information for understanding the results. In addition to the core accounts for 1998 the Appendix Report also presents results for 1996 and a forecast for 2005, the two other years covered by UNITE.

In order to put this report into the context of the UNITE project we start here with a summary of the aims and research areas of UNITE.

The UNITE project endeavours to provide accurate information about the costs, benefits and revenues of all transport modes including the underlying economic, financial, environmental and social factors. To achieve this goal, three main areas of research are carried out, known as "transport accounts", "marginal costs" and "integration of approaches".

This Appendix Report belongs to the research area "transport accounts". For a better understanding of the results presented here it has to be borne in mind that the UNITE project distinguishes between ideal accounts on the one hand and the pilot accounts on the other hand. The ideal accounts reflect the perfect situation with the utmost disaggregation, showing factors such as the time and location and duration of individual trips, all the relevant economic data as well as the individuals response to possible policy or infrastructure changes. The pilot accounts are the actual, feasible accounts given the available data for the 18 countries that UNITE covers. They can be used to assess the costs and revenues of transport per transport mode. The costs are reported and documented at the current level of transport demand for the reference years 1996, 1998 and for the forecast year 2005. Reported transport costs are allocated to user groups, where possible without arbitrary allocation methods.

1.2 The Accounts Approach of UNITE

1.2.1 Aims of the Pilot Accounts

The pilot accounts attempt to show the general relationship between costs of transport and the revenues from transport pricing and charging in the country studied. The aims and role of the pilot accounts are discussed in detail in "The Accounts Approach" Link et al. (2000). It should be stressed that the accounts are aimed at providing the methodological and the empirical basis for in-depth policy analysis (monitoring control) rather than serving as a guide for immediate policy actions such as setting higher/ lower prices and charges or shutting-down transport services/ links in order to achieve cost coverage. The pilot accounts are defined as stated in the box below.

The pilot accounts to be elaborated in UNITE compare social costs and / charges on a national level in order to monitor the development of costs, the financial taxes balance and the structure and level of prices. Accounts can therefore be seen as monitoring and strategic instruments at the same time. They have to consider the country-specific situation and the institutional frameworks.

The pilot accounts show the level of costs and charges as they were in 1998 (and 1996 respectively) and provide a workable methodological framework to enable regular updating of transport accounts. Furthermore, an extrapolation for 2005 is given. The choices of additional accounting years (1996 and 2005) were motivated to show a comparison between years and to give a good indication of trends in transport for the near future. Furthermore, the inclusion of 1996 enables to rule out any major statistical abnormalities that may occur only in one year, for example very high infrastructure cost due to tunnelling operations or higher than average accident costs because of major accidents occurring in 1998.

1.2.2 Core, Supplementary and Excluded Data in the Pilot Accounts

The pilot accounts have been divided into the classes “core data” and “supplementary data”. Core data is the data necessary to do a full basic review of the country accounts. Supplementary data falls into three categories.

- Firstly, data that adds additional information to the core accounts is described as supplementary data.
- Secondly, for several cost categories being evaluated there is no standard methodology for the valuation of effects. An example of this is the valuation of loss of biodiversity due to transport infrastructure. Even though a valuation method has been developed for the UNITE pilot accounts, we feel that the level of uncertainty (due to lack of comparative studies) is high enough to warrant the information to be classified outside of the core data where efficient and well tried valuation methods have been utilised.
- Thirdly, some costs which can be estimated and valuated are borne by the transport users themselves (for example delay costs). These costs and the methods used to valuate them present valuable further information to the reader, but can not be considered to be part of the overall costs of transport as defined by UNITE.

1.2.3 The Six UNITE Pilot Account Cost Categories

Data for the pilot accounts have been collected within six cost and revenue categories that are described in “The Accounts Approach” (Link et al., 2000) and are summarised in the following, non-Swiss-specific sections.

Infrastructure Costs

For the pilot accounts, data for the assessment of infrastructure costs are structured to show the capital costs of transport infrastructure (including new investments and the replacement of assets) and the running costs of transport infrastructure (maintenance, operation and administration) for all modes of transport studied. As far as possible with current methodological knowledge, infrastructure costs are allocated to user groups and types of transport. Where it is possible to quantify the share of joint costs they are sorted out and are not allocated.

Supplier Operating Costs

All monetary costs incurred at transport operators for the provision of transport services are documented in the category supplier operating costs. Ideally, the data is structured to show what costs are incurred for vehicles, for personnel and for administration. However, this depends on data availability and will differ from country to country. Since collecting and supplementing this data for all modes is extremely time consuming the UNITE project focuses on estimating supplier operating costs only for those modes where significant state intervention and subsidisation is present. The main emphasis in this category is thus on public transport (excluding rail) and on rail transport. Whether other modes also have to be covered depends on the degree of state intervention in the respective countries. The corresponding revenues from the users of transport are included when supplier operating costs are estimated. The difference between such costs and revenues is the net public sector contribution (economic subsidy).

Congestion (or Transport User Costs)

In the European Commission's White Paper "Fair payment for infrastructure use" (1998), costs caused by transport delays, accidents and environmental effects of transport are estimated to be the three major causes of external transport costs. In the category transport congestion costs, the costs of delay and delay-caused additional operating costs are estimates. This estimation is intended to provide supplementary data for the accounts and is carried out for all transport modes, provided data are available. This data is classified as supplementary data because the bulk of these costs are borne by transport users as a whole (transport system internal costs).

Accident Costs

The loss of lives and the reduction of health and prosperity through transport accidents are of major concern to all countries and to the European Commission. In this section of the accounts, the health related accident costs are calculated by assessing the loss of production, the risk value and the medical and non-medical rehabilitation of accident victims. Where the available data basis allows, the damage to property and the administrative costs of accidents are considered, too. The external part of accident costs (defined in this report as accident costs imposed by transport users on the rest of society) is included in the core section of the accounts. Total accident costs however, include a substantial proportion of costs imposed by one user on others and are therefore treated as supplementary costs (transport system internal costs).

Environmental Costs

A wide range of transport related environmental impacts and effects, presently being hotly debated in all countries, is considered in this section of the accounts. Included in this cost category are: air pollution, global warming, noise, changes to nature and landscape and nuclear risks. The valuation of these environmental effects is carried out for all transport modes, provided adequate data is available.

It is the aim of UNITE to calculate these costs according to a harmonised methodology. Against this background it was decided to carry out all calculations for air pollution and noise with the EcoSense model running at the Institute of Energy Economics and the Rational Use of Energy of the University of Stuttgart. The model was developed within the series of ExternE Projects on "External Costs of Energy" funded by the European Commission. A description is given in the annex of this report.

Taxes, Charges and Subsidies

Transport taxes and charges are exceptionally heterogeneous throughout Europe. In this section, the level of charging and taxation for the transport sector is documented for each mode of transport. Wherever possible, the revenues from taxes and charges are shown for fixed taxes and charges and variable ones. This information plays an important part in the ongoing discussions about the level of taxation between transport modes and countries. The comparison between taxes levied and the costs of infrastructure provision and use accrued per mode is central to this debate and holds a high level of political significance. Environmental taxes that apply to transportation are separately considered in this section. Taxes such as VAT that do not differ from the standard rate of indirect taxes are excluded from this study.

A further part in this area is reporting on **subsidies**. The need to maintain free and undistorted competition is recognised as being one of the basic principles upon which the EU is built. State aid or subsidies are considered to distort free competition and eventually cause inefficiency. Subsidies to the transport sector provided by the Member States are not exempted from the general provisions on state aid set out in the Amsterdam Treaty. There are, however, special provisions set out in the treaty in order to promote a Common Transport Policy for the transport sectors of the Member States (Treaty establishing the European Community : Articles 70 – 80). The subsidies of the transport sector are considered in this section, however, it should be noted that a complete reporting on subsidies would require extremely time-consuming analyses of public budget expenditures at all administrative levels. Furthermore, the subsidies reported in the pilot accounts refer mainly to direct subsidies (e. g. monetary payments from the state to economic subjects). Indirect subsidies (e. g. tax reductions and tax excemptions that cause lower revenues of state budgets) are not quantified.

1.2.4 The Transport Modes of the Pilot Accounts

The modes covered in UNITE are road, rail, other, i.e. "non-rail" public transport (e.g. tram, trolley bus, urban and regional bus services), inland waterways, short sea shipping and aviation (or air transport). The level of disaggregation into types of networks and nodes, means of transport and user groups depends on data availability and relevance per country. Table 1 summarises this disaggregation for the Swiss Pilot Account. In brackets we give the German notion in order to avoid misinterpretations by Swiss readers of this Appendix Report.

In the case of Switzerland, the two modes inland waterways and short sea shipping are of very minor relevance. Whereas the latter simply doesn't exist, inland waterways is limited to the Rhine harbours in the region of the border town Basel. Against this background, only the calculation of infrastructure costs takes into account the mode inland waterways. In the other cost areas, the Swiss accounts are restricted to the modes road, rail, road based public transport and aviation.

Table 1-1: The modes, network differentiation, transport means and user breakdown in the Swiss Pilot Accounts

Transport modes	Network differentiation	Means and user breakdown
Road	Motorways (Autobahnen) Inter-urban/Rural roads (ausserorts) Urban/Local roads (innerorts)	Motorcycles (Motorräder, Mopeds) Passenger cars (Personenwagen) Coaches (Reisebusse) Light goods vehicles LGV (Lieferwagen bis 3.5 t Gesamtgewicht) Heavy goods vehicles HGV (Schwere Nutzfahrzeuge ab 3.5 t Gesamtgewicht) Others (Landwirtschaftliche Fahrzeuge, Arbeitskarren etc.)
Rail Federal Railways (SBB) and other Railways (non-SBB, so-called Concessionary Transport Companies KTU)	– – –	Passenger transport Freight transport
Road based public transport*	–	Urban and regional diesel buses* Tramways Trolley buses
Aviation	National Airports (Zurich, Basle and Geneva) Flight control services	–
Inland waterways	Harbours only (Basle)	–

* = The transport mode "road based public transport" offers difficulties. Ideally, only the categories buses, tramways and trolley buses are summarised under this mode. In some cases this separation is not feasible. The infrastructure costs of buses, for example, are included in the road infrastructure costs. Against this background, attention should be paid to the footnotes specifying which categories of non-rail public transport could have been taken into account.

1.3 Results Presentation and Guidelines for Interpretation

The goal of the data collection and estimation of cost and revenues in each category was a level of disaggregation that shows the pertinent costs and charges of the relevant transport mode. From the available, but very heterogeneous input data and results, a structure for reporting transport accounts has been developed. All results are documented separately for each cost category and are summarised in modal accounts covering all cost and revenue categories (see chapter 5 of this report).

Additionally, a set of data needed as basic data for all cost categories was collected to ensure that commonly used data are consistent between the cost categories. Minor discrepancies in the basic data used between cost categories are due to the fact that the level of disaggregation in the input data required for each cost category differed.

The cost categories and taxes, charges and subsidies present a comprehensive estimation of transport costs and revenues. They are however, not a total estimation of transport costs. Each cost category could include data in further areas and a definite boarder had to be drawn around the data to be collected for this project. For example, the estimation of environmental costs does not include the environmental costs incurred during the manufacturing of vehicles, even though these costs could be estimated. These costs would be included in an ideal account, but lie outside the scope of the pilot accounts. Further transport costs categories such as vibration as attributing to environmental costs are not evaluated because no acceptable valuation method has been developed.

It should be noted that due to the separation into core and supplementary data with different levels of uncertainty and with different types (costs borne by transport users themselves versus external costs) a simple summing up of the different cost and revenue categories to totals and the calculation of a cost recovery rate is not sensible.

1.4 The Structure of this Report

This annex report contains four major parts:

– In chapter 2, the **input data** used to calculate the figures given in the UNITE Pilot Accounts is presented. The calculations require the collection of a huge amount of figures and information. Chapter 2 does not aim to reproduce all of them but concentrates on the most important input data.

– Chapter 3 deals with **methodological issues**. In some cases, the methodology developed in Link et al (2000) and very briefly summarised in section 1.2.3 above had to be adapted (e.g. because of limited data availability). Chapter 3 concentrates on these deviations from the general accounts approach of UNITE. Furthermore, the procedure to derive the results for the years 1996 and 2005 is described.

– The fourth chapter of the report finally deals with the **results** of the calculations and their interpretation in detail. The descriptions in these chapters are organised along the categories stated in section 1.2.3 above.

– In the last chapter, the detailed results of chapter 4 are finally brought together per mode. This **final presentation of the results** is the same for the different UNITE countries.

2 Input Data

This chapter is divided into seven sections. The first section 2.1 presents the basic economic and transport data used for the calculations of several types of costs. The subsequent six sections discuss the most important specific input data on which the assessment of the cost and revenue categories of UNITE is based. These categories are:

- Infrastructure costs (section 2.2),
- Supplier operating costs (2.3),
- Congestion costs (2.4),
- Accident costs (2.5),
- Environmental costs (2.6),
- Taxes, charges and subsidies (2.7).

Each of the six sections starts with a very short description of the main data needs of each individual cost and revenue category. As mentioned in section 1.3, we renounce repeating the detailed description of the methodology applied for the calculations of transport costs and revenues which is given in Link et al. (2000). The presentation of the input data is restricted to the most important values and figures but does not aim to reproduce all the data that has been collected for the calculations.

The data availability, the level of disaggregation and the quality of the input data differs considerably between and within the different cost categories. These differences of course influence the level of uncertainty of the results of our calculations. In order to make them transparent to the reader the following sections also contain - where useful - a judgement of the data quality.

2.1 General Input Data

2.1.1 Basic Economic and Structural Data

In some cases, basic economic data is needed as inputs for the calculation of transport costs. In Nellthorp et al. (2001) it is, for example, defined that values (e.g. value of time, value of statistical life) grow with real incomes. Accordingly, the cost estimates for the year 2005 need information about the growth of the Swiss GDP. The following table contains the most important basic economic data used in our cost estimations. It is given for the base year of UNITE (1998) and the two backcast and forecast years 1996 and 2005.

The figures for the year 2005 are partly based on official forecasts (population), on trend extrapolation of the last 20 years (real GDP growth rate per year of 1.4%) or estimates of the further development (price index, inflation rate of 1%/a).

Table 2-1: Basic economic and structural data for Switzerland[1]

Data	Unit	1996	1998	2005
Land area	sqkm	41 285	41 285	41 285
Population	million	7. 081	7. 124	7. 244
GDP (in current prices)	€ million	228 646	235 148	277 880
GDP (in 1998 prices)	€ million	229 972	235 148	259 183
GDP / capita (in 1998 prices)	€	32 477	33 010	35 781
Growth of GDP / capita per period	%		1.6%	8.4%
Consumer price index	index	103.4	104.0	111.5

2.1.2 Basic Transport Data

Most of the transport data used for the calculation of the different costs and revenues is summarised in the following sections 2.2 to 2.7. Here, we concentrate on the basic information about transport volumes in the three UNITE years, i.e. the base year 1998 and the backcast and forecast years 1996 and 2005 respectively. These figures are used to derive cost rates per unit of performance in the chapters with the results for each cost category (chapter 4).

Table 2-2 shows the figures for the different modes of **road transport**. The figures are differentiated according to the road infrastructure type.[2] For this mode, detailed information is available about past, current and future transport volumes. The figures in the table make clear that all road transport modes - with the exemption of moped - are expected to grow between the UNITE base year 1998 and the forecast year 2005. The largest growth rate is predicted for light goods vehicles and coaches.

1 Source: Federal Office for Statistics.

2 The data available in Switzerland does not allow to follow the "UNITE-distinction" between motorways, state roads, regional roads and urban roads. The common distinction used in Switzerland is motorways, roads outside built up areas (inter-urban/rural roads) and roads inside built up areas (urban/local roads).

Table 2-2: Transport volumes of road transport in Switzerland, in mill. vkm[3]

Mode	Road infrastructure	1996	1998	2005
Moped	**Total**	**389**	**355**	**308**
	Motorways	0	0	0
	Inter-urban/Rural roads	78	71	62
	Urban/Local roads	311	284	246
Motorcycle	**Total**	**1 358**	**1 435**	**1 552**
	Motorways	243	256	295
	Inter-urban/Rural roads	670	708	748
	Urban/Local roads	445	471	509
Car	**Total**	**45 891**	**47 554**	**50 712**
	Motorways	13 667	14 162	16 055
	Inter-urban/Rural roads	17 182	17 805	18 616
	Urban/Local roads	15 042	15 587	16 041
Bus*	**Total**	**194**	**196**	**202**
	Motorways	0	0	0
	Inter-urban/Rural roads	69	70	72
	Urban/Local roads	125	126	130
Coach	**Total**	**109**	**114**	**144**
	Motorways	50	52	66
	Inter-urban/Rural roads	37	39	49
	Urban/Local roads	22	23	29
Light goods vehicle	**Total**	**2 872**	**3 077**	**3 810**
	Motorways	952	1 020	1 303
	Inter-urban/Rural roads	1 026	1 099	1 332
	Urban/Local roads	894	958	1 174
Heavy goods vehicle	**Total**	**2 260**	**2 433**	**2 530**
	Motorways	1 064	1 156	1 184
	Inter-urban/Rural roads	767	819	867
	Urban/Local roads	429	458	479

* Public buses: Urban and regional bus services

Table 2-3 summarises the situation and development for **rail transport**. It is distinguished between the Federal railway company SBB and the other companies so called concessionary transport companies. The SBB produce more than 70% of the total train-kilometres of the Swiss railway companies.

Whereas forecasts of the SBB assume a further growth of the traffic performance between 1998 and 2003 of about 4%, there seems to be no relevant growth or even a decrease for the other railway companies unless there is a trend reversal compared to the last ten years. The

3 Figures from the Federal Office for Spatial Development, used in BUWAL (2000).

figures for the year 2005 base on the SBB forecast and on the assumption that there is no growth in the case of the other railway companies.

Table 2-3: Transport volumes of rail transport in Switzerland, in mill. train-km[4]

Railway companies	1996	1998*	2005
Federal company (SBB)	**115.8**	**116.8**	**121.7**
Passenger transport	89.8	90.7	94.4
Freight transport	26.0	26.1	27.4
Other companies	**43.0**	**43.7**	**43.6**
Passenger transport	40.4	41.1	41.0
Freight transport	2.6	2.6	2.6
Total rail	**158.8**	**160.5**	**165.3**
Passenger transport	130.2	131.8	135.4
Freight transport	28.6	28.7	30.0

* = figures of 1997

As mentioned in section 1.2, the UNITE mode category "**Public transport**" covers modes which are normally contained in other mode categories: Diesel buses are part of road transport and urban rail services are included in the mode rail transport. Whereas the first category can be separated from road transport, this is not possible in the case of urban railway services. Therefore, the table below only contains figures on **road based public transport modes** and tramways.

Table 2-4: Transport volumes of road based public transport in Switzerland, in mill. vkm[5]

Mode	1996	1998	2005
Total	**266.6**	**271.2**	**282.1**
Regional bus services	147.3	146.8	151.2
Urban/local bus services	46.6	49.0	50.4
Tramway	41.0	43.0	47.2
Trolley bus	31.7	32.4	33.3

As in the case of rail transport, the increase in traffic performance of road based public transport between 1998 and 2005 is - following the trend development in the last years - assumed to be rather limited. It amounts to about 4% over the whole period.

A strongly different picture is given when it comes to the growth rates in **aviation**. In table 2-5 some key indicators are presented that give evidence to the enormous development forecasted for aviation in Switzerland. The first four lines of the table show the figures for total air transport, i.e. movements of commercial and private aircrafts on all relevant airports and airfields in Switzerland.[6]

4 Sources: BFS (2000), SBB Mittelfristplan 1999-2003 and Maibach et al. (1999).

5 Sources: BFS (2000) and BFS (2001).

6 The ground infrastructure of aviation consists of 3 national and 8 regional airports, 39 airfields and 25 land-

For UNITE, the lower part of the table is of relevance. It shows the numbers of aircraft movements of commercial and charter traffic on the three national airports Zurich, Geneva and Basle. Again, a large increase in aircraft movements of almost 30% (or more than 3.5% per year) can be identified between 1998 and 2005. Beyond 2005 a somewhat lower annual growth rate is expected. The figures base on a detailed forecast commissioned by the Swiss Federal Office for Civil Aviation.

Table 2-5: Transport volumes of aviation in Switzerland, in 1 000 aircraft movements[7]

Total air transport	**1996**	**1998**	**2005**
Commercial traffic	**497**	**580**	**750**
Scheduled and charter traffic	428	465	602
Others (Taxi, flips)	68	115	148
Private traffic	**968**	**884**	**n.a.**
National airports*	**1996**	**1998**	**2005**
Total	**394**	**438**	**564**
Zurich	224	252	330
Geneva	102	105	118
Basle	68	81	116

* = only scheduled and charter traffic

2.2 Infrastructure Costs

2.2.1 Road

Our estimation is based on the official national values. The official Swiss road accounts published periodically by the Federal Statistical Office (BFS, 1998/2000) show cost categories (current costs, capacity costs and weight related costs) and related revenues for 30 different vehicle categories. Based on this information a cost coverage for each vehicle category is shown.

The Swiss road account is based on the assumption that 100% of the costs of motorways, 90% of cantonal roads and 70% of municipal roads are attributable to vehicles, the rest to other purposes. The Swiss road account estimates capital costs by the perpetual inventory method (considering an average depreciation rate and interest rates based on national refinancing costs). The road costs are allocated according to costs-by-cause principle.

The road account differs between current costs, capacity costs and load related costs. The total amount of infrastructure costs road are allocated within the Swiss road account according to different indicators. Current costs are allocated according to the specific mileage of the different vehicle types. 80% of the capacity costs are allocated according to the indicator "mileage multiplied with the length of the vehicle" and 20% of the capacity costs are allo-

ing places for helicopters (Source: BAZL, 2000).

7 Sources: BAZL (several publications) and ITA (1999).

cated according to the mileage. The allocation of the load related costs is made by using the indicators axle weight and axle weight factor.

2.2.2 Rail

The Swiss Federal Statistical Office (BFS) publishes every year the figures for the Swiss rail account. These figures show costs and revenues for all railway companies for different cost and revenue categories. These figures provide a basis for the calculations for 1998 and 1996. According to these figures no separation of the rail category infrastructure (as well as passenger and freight) is possible, therefore a more detailed rail account had to be generated. The data input for the new rail account is based on the profit and loss accounts (divided into the categories infrastructure, transportation of passengers and freight) and the detailed asset and depreciation accounts of all railway companies.

2.2.3 Road Based Public Transport

The infrastructure costs for buses are covered in the Swiss road account mentioned above, although only at national level. Detailed information for city related infrastructure (like tramways, etc.) is not fully available. For urban public transport therefore all business account information covering infrastructure and operating costs is contained in the supplier operating costs.

2.2.4 Aviation

The accounts for infrastructure air in our Swiss pilot account cover the three national airports (Zurich, Geneva, Basle) and the air traffic control in Switzerland (Skyguide). The basic information stems from the annual financial reports of these companies. For the pilot accounts we did not consider all the regional airports and private airfields, since they are of minor relevance for civil aviation. The airports Zurich, Geneva and Basle have 97.7% of the passengers and 99.8% of the airfreight (in tonnes) of Switzerland (BAZL, 1999). An additional information source were the figures of the hidden subsidies from public authorities for the national airports. This data stems from the national and relevant cantonal departments, based on interviews and different financial reports of the respective public authorities.

2.2.5 Inland Waterways

In Switzerland the infrastructure for inland waterways is very minor because infrastructure on the lakes in Switzerland (leisure) does not have to be considered. We concentrated our analysis on the Rhine ports located on the Swiss border in Basle. The input data stems from the annual reports from the two ports in Basle. Additional information such as hidden subsidies originate from the public authorities of the Cantons Basle-Land and Basle-Stadt.

2.2.6 Summary of Input Data

The following table gives an overview of the characteristics of the input data used per transport mode.

Table 2-6: Input data for the computation of infrastructure costs by transport mode

Infrastructure	Input data	level of disaggregation	Quality of data, level of uncertainty
Road	Financial data (costs, revenues) from the Swiss Federal Statistical Office (official Swiss road account). Yearly data available.	30 vehicle categories and corresponding costs and revenues per category. The costs are differentiated in current costs (2 categories), capacity costs and load related costs (2 categories)	High quality In the data sets for 1996 and 1998 no major uncertainties.
Rail	Financial data (costs, revenues, subsidies). Data sources are the annual reports of all the railway companies showing a differentiation of the category infrastructure costs (and passenger and freight. Asset and depreciation accounts of all railway companies. Information about hidden subsidies from the Federal Office of Transport. Financial data (costs, revenues) from the Swiss Federal Statistical Office (official Swiss rail account). Yearly data available.	Within the cost accounts the diseggregation was available as follows: Personnel, materials, other running costs, cross-sectoral costs, special costs, depreciation, interests.	For 1998 some information is lacking from one important railway company. For 1996 the necessary detailed information is not available (changes in reporting system). Lack of differentiation
Aviation	Financial data (costs, revenues, subsidies). Data sources are the annual reports of all the three national airports and the flight control company in Switzerland. Information about hidden subsidies from the Swiss Federal Office for Civil Aviation and the cantonal offices for aviation of the relevant Cantons.	In the cost accounts the disaggregation was available as follows: Current costs, taxes and charges, personnel costs, depreciation, interest rates and exchange rate losses, extraordinary costs. In the revenue accounts the disaggregation was available as follows: Airport taxes, rents, user charges, additional revenues, commercial charges, other services, financial benefits, extraordinary benefits.	It is not possible to separate costs and revenues connected with the infrastructure for aviation. From the revenues some are clearly attributable to infrastructure (e.g. airport taxes), but on the cost side no separation can be made between flight and non-flight business. Therefore we show today the whole block of costs and revenues, but as detailed as possible. No asset and depreciation accounts of the companies available so far.

Infrastructure	Input data	level of disaggregation	Quality of data, level of uncertainty
Inland Waterway	Financial data (costs, revenues) from the annual reports of the two Rhine Ports. Yearly data available. Information from the cantonal office of finance (one port is owned by the Canton). Information about hidden subsidies from the cantonal offices of Basle-Land and Basle-Stadt.. Asset and depreciation account of one port.	Within the cost accounts the disaggregation was available as follows: Administration, personnel, maintenance, energy, other running costs, depreciation, interests.	Data set for 1996 and 1998. It is not possible to differ between infrastructure and other costs in the annual reports. We treated the two ports as infrastructure solely (no supplier operating costs). Asset and depreciation account of one port missing.

2.3 Supplier Operating Costs

2.3.1 Rail

Basically, for the estimation of rail supplier operating costs the same input data as for infrastructure was used. Basis for all computations are the Swiss rail accounts (provided every year by the BFS), which contain data on costs and revenues for all railways in Switzerland in aggregated cost/revenue categories (personnel costs, material costs and running costs).[8]

However, for the purposes of the presented study, more detailed categories have to be analysed. For 1998 a more detailed sectoral account (see section 2.2.2) of the Swiss Federal Railways was generated, which shows costs and revenues in more detail (costs for material, goods, services, personnel, VAT, cross-sectoral costs, special costs, etc). Furthermore, these costs/revenues are allocated in all subdivisions (infrastructure, transportation of passengers/ freight and central services). The Federal Railways mid-term business plan provides projected costs and revenues up to the year 2004. Projections for 2005 are based on this data.

2.3.2 Road Based Public Transport

Financial data of urban and regional public transport official statistics (see BFS, 1997 and BFS, 1998) is divided in two main categories:

1. **UPT** (Urban Public Transport): Category includes 16 urban public transport companies in major cities and suburban areas formerly owned by municipalities. Recently some of them have been converted into public companies.
   Modes: tramway, trolley bus, urban/local bus (diesel)
2. **RBS** (Regional Bus Services): Category with at present 164 so-called 'Concessionary Transport Companies', which offer bus services mainly in rural areas. Operation of these services needs a concession which is issued by the regional government and assigned to the companies in a tendering procedure.
   Mode: regional diesel bus

8 Details on methodological aspects in INFRAS (2000).

A separate survey within the 16 UPT and more than 150 RBS companies was not feasible. Therefore, the main data source for supplier operating cost data in public transport consists of the official statistics of the Swiss Federal Statistical Office BFS. The BFS collects on an annual basis technical, transport-related and financial data directly from public transport companies.

As a result of the liberalisation in urban as well as in regional public transport, data availability especially for the most recent years (from 1996 onwards) was particularly poor. The main problems occurred within the financial data sector of which official data was not available.

However, a provisional, incomplete data set for the years 1996-1998 could be used. The main problem with recent financial data on urban and regional public transport is a lack of differentiation of the relevant cost categories. Due to the format of data, separation into fixed and variable supplier operating cost categories was not possible.

The table below shows the relevant input data categories, their level or disaggregation and uncertainty:

Table 2-7: Input data for the computation of supplier operating costs by transport mode

	Input data	**level of disaggregation**	**Quality of data, level of uncertainty**
UPT	a) Transport data for tramway, trolley buses and urban buses: Passenger, passenger-km, vehicle-km from 1990 on to 1997 with provisional data for 1998	Modes UPT: Tramway, trolley bus, diesel bus	Data set 1998: 2 companies provided only incomplete figures Passenger/passenger-km: due to methodological changes in passenger counting, time series of the number of passengers as well as the number of passenger-km show non-plausible trends
	b) Financial Data (costs, revenues): complete time series from 1990 on to 1995. Provisional and partly incomplete time series from 1996-1998.	UPT: Integral account for each Urban Public Transport Company, no differentiation between tramway, trolley bus, bus Within the cost accounts only a rough disaggregation was available (personnel, materials, goods, services, depreciation, interests, other costs).	Especially 1997 and 1998 incomplete and due to methodological changes not comparable with previous time series Lack of differentiation
RBS	a) Transport data: Passenger, passenger-km, vehicle-km from 1990 on to 1995 with provisional data for 1996-1998	Mode: Diesel bus	Data set 1998: ca. 5% of all public transport companies did not delivered transport data (data for 1997 have been used for those companies.)
	b) Financial Data (costs, revenues, subsidies): Complete time series from 1990 on to 1995, provisional and partly incomplete time series from 1996-1998	Within the cost accounts only a rough disaggregation was available (personnel, materials, goods, services, depreciation, interests, other costs).	Data set 1996-1998: some companies did not deliver financial data (data for 1997 have been used for those companies)

2.4 Congestion Costs

2.4.1 Values of Time

The values of time (VOT) per passenger-hour are taken from the UNITE valuation paper (Nellthorp et al., 2001)[9], PPP-adjusted and converted into factor costs (commuting and leisure values only). According to the valuation paper (Nellthorp et al., (2001) it was assumed that Values of Time grow over time in line with real incomes (elasticity of 1.0 to the country's real GDP per capita). The respective values (GDP per capita) are taken from table 2-1.

Table 2-8: VOT-Values for Switzerland (PPP-adjusted values, Nellthorp et al. (2001), in € per hour, 1998 prices

	1996			1998			2005		
	Business	Commuting	Leisure	Business	Commuting	Leisure	Business	Commuting	Leisure
Car	37.35	9.91	6.60	38.52	10.22	6.81	40.93	10.86	7.24
Inter-urban rail	37.35	10.57	7.76	38.52	10.90	8.01	40.93	11.58	8.51
Coach	37.35	9.91	6.60	38.52	10.22	6.81	40.93	10.86	7.24
Air	50.68	16.51	16.51	52.28	17.03	17.03	55.55	18.10	18.10
Urban bus/ Tramway	37.35	9.91	5.28	38.52	10.22	5.45	40.93	10.86	5.79

2.4.2 Input Data by Mode

The following tables show the different data sets used by mode to estimate congestion costs. The calculation of congestion costs in road transport is based on the official Swiss congestion cost study (ASTRA, 1998), carried out by INFRAS. Data which was used in that study was updated and additional data added.

Table 2-9: Input data, uncertainties and level of disaggregation for the computation of congestion costs for road transport

	Input data	Level of disaggregation	Quality of data, level of uncertainty
Road	a) Swiss Federal Roads Office: Yearly report on congestion on Switzerlands motorways 1998 (figures 1995-1998)	Traffic jams by purpose (congestion hours), road	Methodological change in 1996, so reports 1998 and 1995/1996 are not comparable Reports only on traffic jams on motorways
	b) Model calculations based on a traffic flow fundamental diagram and traffic models (ASTRA, 1998)	Modes: Car, HGV, LGV	Traffic model allows only calculation for motorways

9 For the calculation of the user costs, i.e. delay costs, the factor 1.5 as proposed in Nellthorp et al. (2001) to adjust for the higher value of delay time compared to expected travel time - the VOT estimates given in Nellthorp et al. (2001) refer to the latter - has been applied.

	Input data	Level of disaggregation	Quality of data, level of uncertainty
	c) Overall estimates concerning time delays based on difference between average travel speeds in peak-hours versus off-peak-conditions (ASTRA, 1998)	Modes: Car Road types: Motorway, inter-urban roads, urban/local roads	Rough estimates of speed differences, results couldn't be empirically verified
	d) Model calculation of congestion in urban areas in Zurich and Bern, extrapolation to all cities and agglomerations with more than 15 000 inhabitants (ASTRA, 1998)	Modes: Car	Rough estimates of extended travel times in peak-hours
	e) Results of a recent study on congestion costs in the Canton of Zug/Switzerland. Congestion costs are estimated based on a measuring program of travel times in peak hours vs. off-peak hours	Modes: Car, HGV, LGV Road types: Motorways, inter-urban/rural roads, urban/local roads	First study in Switzerland, were based on a sample effective travel times have been measured. High quality of data for urban roads and motorways, no typical inter-urban/rural roads inside the study region
	f) Vehicle occupancy rate per purpose of trip: analysis of the 'Mikrozensus Verkehr 1994' (BFS, 1996)	Business, commuting, leisure weekdays, weekends	Official Rates by the Swiss Federal Statistical Office Values for 1994, no more update values available
	g) Total mileage1996, 1998, 2005: Handbook for Emission Factors in Road Transport – mileage database (HBEFA (1999), BUWAL (2000)).	Modes: Car, HGV, LGV, motorcycle, coach, bus	Official mileage database based on transport statistics and up-to-date traffic forecast
	h) Fuel prices 1996, 1998: Average prices of the respective year provided by the Touring Club Switzerland (TCS)	Gasoline, Diesel	Average values

Congestion costs in rail, urban public and air transport are calculated for the first time in Switzerland. The following table shows the most important input data categories.

Table 2-10: Input data, uncertainties and level of disaggregation for the computation of congestion costs for rail, public transport and aviation

	Input data	Level of disaggregation	Quality of data, level of uncertainty
Rail Pass.	a) Distribution of arrival delays (number of trains per delay class, e.g. 5:00-6:00 minutes) for the year 2000. Range: -5 to +30 minutes.	Train categories for the year 2000. Categories are: EC/IC, direct trains, regional trains/S-Bahn	Data for 2000 only Sample of 12 major stations (used by the Swiss Federal Railways SBB for their quality assessment) 5-minute benchmark for passenger trains is used by SBB for their punctuality statistics and was adapted for our purpose, i.e. only trains more than 5 minutes late are counted
	b) Distribution of passengers over one day from 1996 on to 1998.	Train categories	
	c) Punctuality index (percentage of trains arriving less than 5:00 minutes late) over one day.	Train categories	Data from Zurich Main Station for January 2001 only.
	d) Number of passengers for 1995-2000. e) Travel-purpose-split for each train category.	Train categories Business, commuting, leisure	Assumptions based on survey ("Mikrozensus", see BFS, (1996))
	f) Valuation of time (inter urban rail - in vehicle waiting time – congested/delayed)		
Rail Freight	a) Delay-distribution (number of trains per delay-class). Range: -5 to 60 minutes	Inland and import/export, transit traffic	Sample of 7 major Swiss Stations and further strategic points on the network (marshalling yards, borders) Only first provisional data available, data so far not approved For freight trains a 15-minute benchmark was agreed on
	b) Performance of freight trains (tonnes). Figures from 1995 to 2000	Inland and import/export, transit traffic	Official data from business accounts and official statistics (Swiss Federal Statistical Office)
	c) Valuation of time (Rail freight)		

	Input data	Level of disaggregation	Quality of data, level of uncertainty
Aviation	a) Number of delayed passengers for each delay class (e.g. 5-10 minutes). Range from 0 to “60 and more” minutes Source: Swiss Federal Office for Civil Aviation (BAZL), electronic database (not published).	Swiss and foreign companies Charter and scheduled flights	No data for 1996, 1997 was used instead
	b) Travel-purpose-split	Business, leisure (commuting negligible)	No empirical background for assumption (federal survey for 2000 in preparation) – estimations with two scenarios
	c) Valuation of time (air- in vehicle waiting time – congested/delayed, Nellthorp et al. (2001))		
UPT	a) Travel time differences peak - off-peak within Zurich (VBZ: UPT company Zurich) 1999-2000 Travel time differences peak – off-peak are taken into account into timetable design (different timetables for peak and off-peak periods). Data used to calculate 'Small delays'	Tramway, trolley bus, bus Definition time-period peak – off-peak: peak: 06.15-08.15 am 16.00-18.00 pm off-peak: 19.30-24.00	No data available for 1998: according to information from the operator (VBZ) the measured time differences have not changed significantly since 1998 Extrapolation of the Zurich data for Switzerland (see Methodology-chapter)
	b) Extraordinary delays (more than 3 minutes) for 1996-2000) registered semi-automatically by the UPT-operation centre in Zurich Data used to calculate delays of more than 3 minutes (deviations from timetable)	Tramway, trolley bus, bus (disaggregation calculated by INFRAS based on an random sample of delays)	Complete data set only available for Zurich (the other UPT transport companies in Switzerland don't collect delay data on a standardised methodology) Extrapolation of the Zurich data for Switzerland (see Methodology-chapter)
	c) Disaggregated demand data (passenger, passenger-km) for 1998-2000 for Zurich	Tramway, trolley bus, bus (diesel), small buses	Demand data derived from random samples
	d) Demand data (passenger) UPT Switzerland: time series 1990-1998)	Tramway, trolley bus, bus	See chapter 2.3 (supplier operating costs)

2.5 Accident Costs

The methodology and steps to calculate the costs of transport accidents is described in Link et al. (2000) and especially in Doll et al. (2000). In these documents, comprehensive lists of data requirements are stated. For the assessment of total accident costs, input data concerning several cost blocks has to be collected. The table below summarises the main cost blocks that add up to the total costs of traffic accidents.

Table 2-11: Cost blocks of the total traffic accident costs

Cost blocks	Valuation issue
Material damages	Valuation of damages to vehicles, parts of the infrastructure etc. involved in traffic accidents
Administrative costs	Costs connected with the treatment of accidents by the police, the legal system, the social security and insurance companies
Medical costs	Costs connected with the treatment of injuries caused by traffic accidents
Production losses	Current and future lost output of victims of traffic accidents, replacement costs of the firms
Risk costs	Valuation of fatalities and injuries caused by accidents

In addition to the cost blocks, information about the payments of insurance companies and transfers of the social security has to be collected. In the following section "Input data" we summarise the most important values and their sources we used for the calculations of the different cost blocks for the UNITE transport modes.

2.5.1 Road

The number of road accidents is published annually by the Swiss Federal Statistical Office BFS in a very detailed way with regard to the different vehicle categories involved and the severity of the accidents. Furthermore, the data set on road accidents contains the information about the cause of the accidents. Therefore, it is possible not only to present the accident costs by victims but also by the causer. Within the UNITE project it has been decided that due to data constraints for most countries the detailed analysis of accident costs is based on the victim perspective. In Switzerland, accident costs are published according to the causer perspective. The choice of the perspective has consequences for the possibilities to calculate the external accident costs for the different vehicle categories (see section 3.2.5 below).

Because the official data published by the Federal Office for Statistics only contains accidents recorded by the police, the main uncertainty with regard to the number of road accidents refers to injuries caused by non-reported accidents. Due specific evaluations carried out at the Sammelstelle der schweizerischen Unfallversicherungen (“Collecting Office of the Swiss Accident Insurances”) it was possible to obtain new empirically based information about the non-reported accidents (see box below).

Evaluation of the number of injuries caused by non-reported accidents: The following sources have been used to assess the number of non-reported accidents:

a) The statistics of the accident insurances in Switzerland: This statistics contains all accidents of employees. A random sample has been used to make a projection for the total number of people of working age injured by a road accident.

b) A special evaluation of the number of children injured by road accidents carried out in the early nineties (Allenbach, 2000): The figures given in this special evaluation have been adjusted to the year 1998.

c) Statistics of hospitals and physicians containing information about the number of seniors involved in road accidents: Again, a random sample has been drawn to assess the relevant figure for the year 1998.

Using these sources the number of injuries amounts to 100 380 persons. In the official accident statistics based on police reports a number of 27 562 is given. Obviously, a very large number of accidents with people injured is not reported to the police. It can be assumed that in most cases the injured person also caused the accident and didn't call the police to avoid any penance. And, underreporting first of all refers to accidents with light injuries only.

80% of the injured people belong to the group "people of working age". For this category, our assessment of under-reporting bases on a highly reliable database. Accordingly, also the total number of non-reported accidents can be considered as a rather reliable estimate.

Even in the case of fatalities we found in our calculations a small deviation from the figures given in the official statistics, i.e. 588 and 597 fatalities. Here, however, the reason are differences in the time horizon: Whereas the official statistics only counts fatalities up to one month after the accident occurred, the statistics of the insurance companies take into account a much larger period.

In the table below, the official figures for fatalities and injuries are complemented with the results from the analysis of non-reported accidents. The table follows the victim or **"monitoring" perspective of UNITE**. The rows show the vehicle categories of the victims of road accidents, the column the involvement of the vehicle categories.

Because the work within UNITE in this cost field was co-ordinated with an in-depth study on accident costs for the Swiss Federal Office for Spatial Development, it was possible to carry out a detailed data collection for the valuation of the accidents: The table 2-13 summarises the main data sources and contains a brief assessment of the reliability of the data collected. The summary shows that in general, this reliability is high compared to the existing uncertainties in other cost categories (e.g. noise costs).

Table 2-12: Number of killed and injured victims of road accidents, 1998

Involved element / Victim	All	Non-reported	Reported accidents (official figure)										
			Single accidents	Two party accidents									Several party accidents
				Pedestr., cycle	Motor-cycle	Car	Coach	PT	LGV	HGV	Rail	Others	
All													
Accidents*	66 581		21 417	2 932	2 655	30 254	308	428	1 584	1 513	68	195	5 229
Fatalities	597	8	185	11	15	193	6	14	22	45	4	12	82
Injuries	100 380	53 421	5 814	861	1 075	13 618	144	302	871	736	35	110	3 995
Pedestr., cycle													
Accidents*	3 901		585	291	180	2 163	16	66	122	80	2	15	384
Fatalities	173	3	7	3	4	79	2	10	12	14	0	7	33
Injuries	34 303	28 158	553	356	354	3 356	24	125	196	132	3	18	1 027
Motorcycle													
Accidents*	4 225		1 223	180	140	2 153	17	10	94	44	1	17	348
Fatalities	96	2	31	2	4	33	2	2	0	3	1	3	13
Injuries	23 763	18 541	1 089	96	193	2 810	22	21	142	63	1	25	759
Car													
Accidents*	51 995		17 780	2 163	2 153	22 939	241	303	1 148	1 115	51	143	3 961
Fatalities	302	5	130	5	6	78	2	2	10	26	3	2	34
Injuries	38 491	23 105	3 874	381	496	7 283	87	131	488	452	24	57	2 115
Coach**													
Accidents*	493		145	16	17	241	8	5	9	13	1	1	40
Fatalities	3	0	3	0	0	0	0	0	0	0	0	0	0
Injuries	971	856	56	1	2	25	0	1	7	12	0	1	11
PT***													
Accidents*	495		12	66	10	303	5	6	21	16	1	2	56
Fatalities	0	0	0	0	0	0	0	0	0	0	0	0	0
Injuries	412	363	5	0	0	15	0	15	4	2	0	0	8
LGV													
Accidents*	2 617		826	122	94	1 148	9	21	95	80	7	10	207
Fatalities	8	0	4	0	0	1	0	0	0	2	0	0	1
Injuries	1 234	908	124	17	21	54	8	7	20	31	4	4	37
HGV													
Accidents*	2 454		743	80	44	1 115	13	16	80	153	6	8	198
Fatalities	7	0	4	0	0	1	0	0	1	0	0	0	1
Injuries	816	600	63	9	6	50	2	2	10	40	2	3	28
Rail													
Accidents*	76		0	2	1	51	1	1	7	6	0	1	9
Fatalities	0	0	0	0	0	0	0	0	0	0	0	0	0
Injuries	4	3	0	0	0	0	0	0	0	1	0	0	0
Others													
Accidents*	324		103	15	17	143	1	2	10	8	1	1	26
Fatalities	9	0	6	0	1	1	0	0	0	0	0	0	0
Injuries	386	284	50	2	4	25	1	1	4	4	1	2	10

* = only number of reported accidents
** = incl. mini buses
*** = public buses, trolley buses and tramways

Table 2-13: Input data for the valuation of the road accidents

Cost category	Data sources, main input data	Level of disaggregation	Quality of data, level of uncertainty
Material damages	Total payments of auto physical damage and auto liability insurances, only vehicle damages Figures: See result tables in section 4.4	Detailed information per vehicle category, stronger disaggregation than the UNITE categories	High quality pool data of all insurance companies offering services in Switzerland
Administrative costs	Statistics and direct information of insurance companies and police departments about the adm. costs connected with the treatment of cases of accidents <u>Administrative cost categories:</u> - Social Insurance comp. 9% of payments - Auto physical damage and auto liability Insurance companies: 20% of payments - Police: € 408 / case - Legal System: € 3 460 / case	Insurance companies: percentage rate on total payments for material damages and damages to persons Police and legal System: rate per case of accident	Plausible estimates
Medical costs	Special evaluation of the central statistics of the Swiss accident insurances and direct information from hospitals (further charging of costs) and insurance companies Average medical treatment costs in €: <u>Severity of accident — women — men</u> Fatality: 6 732 — 4 875 Injury severe perm: 29 553 — 43 011 Injury severe temp: 2 990 — 2 482 Light injury: 313 — 267	Average figures per case in each accident category, distinction between temporary and stationary treatment	Rather high quality of data
Production losses	The net production value (i.e. total production value minus own consumption) is taken from National statistics: Value used (production factor labour only), i.e. the average income: € 11 725 / year Value for a sensitivity analysis: Production potential including all factors (i.e. labour, capital, ground): € 28 407 / year Direct information on replacement costs from different companies: The rate in % of an annual wage varies from 10% (low qualified) to significantly more than 100% Value used: 50%	Swiss average value	Good data in the case of the net production losses, plausible estimate in the case of the replacement costs

Cost category	Data sources, main input data	Level of disaggre-gation	Quality of data, level of uncertainty
Risk value (Value of Statistical Life VOSL)	Source: Valuation conventions of UNITE[10] VOSL: € 1.5 mill. Adjustments: - Income, adjustment factor: 1.2704 - Factor costs, adjustment factor: 0.077 VOSL after adjustment: € 1.77 Value for injuries in % of VOSL: - Severe permanent: 32% - Severe temporary: 9% - Light: 1%	- -	In a WHO study (Sommer et al., 1999) on health costs a VOSL of € 1.5 mill. has been applied. A Swiss pilot study (Schwab N and Soguel N, 1995) contains an estimate of € 1.05 mill. / fatality
Payments of auto liability insurances and transfers of the social security	National Statistics for total payments of the social security, detailed information from insurance companies and the Swiss Federal Office for Social Security for payments of the liability insurances Total transfer payments: € 453 mill. Total liability insurance paym.: € 583 mill.	Average figures for each accident category (i.e. accident severity)	High quality of data

2.5.2 Rail

The number of fatalities and injuries caused by rail accident is annually published. The statistics contain detailed information about the different type of accidents (e.g. accidents during shunting, involved categories of persons (employees, passengers and third parties), accidents on level crossings). However, the distinction between freight and passengers trains is not made. The traffic performance of both categories have been used to allocate the accidents.

In contrast to road transport, the problem of underreporting is of minor relevance in the case of rail transport: Only petty accidents are not reported. From the point of view of costs they are unimportant. The table below summarises to total number of fatalities and injuries caused by rail accidents.

The valuation of the rail accidents bases on the same cost figures and their sources as given in the table 2-13 with the exemptions of the costs for material damages and payments of insurance companies. These figures base on information from the Swiss Federal Railways SBB. They are given in the result tables in section 4.4.

10 For the figures in this cell see Nellthorp et al. (2001), Valuation Conventions for UNITE, Annex V.

Table 2-14: Number of killed and injured victims of rail accidents, 1998

Category of rail transport	**All**	Reasons for accidents		
Victim		Collision	Derailment	Others
All				
Accidents	207	139	13	55
Fatalities	32			
Injuries	32			
Passengers transport				
Accidents	170	114	11	45
Fatalities				
Travellers	5			
Employees	3			
Injuries				
Travellers	8			
Employees	6			
Freight transport				
Accidents	37	25	2	10
Fatalities				
Travellers	1			
Employees	1			
Injuries				
Travellers	2			
Employees	1			
Third parties				
Fatalities	22			
Injuries	15			

2.5.3 Road Based Public Transport

The category public transport (PT) in table 2-12 contains all public buses, trolley buses and tramways. For a differentiation between urban and non-urban public transport services within the presentation of the results, the distribution of the mileage to the different type of road infrastructure (see table 2.2) can be used to roughly estimate the accident costs of buses travelling in urban areas.

The valuation bases on the same sources as summarised in table 2-13.

2.5.4 Aviation

The number of accidents with fatalities and injuries considerably varies between different years. Therefore, we have chosen an eleven-year average to define the relevant number of accidents and victims. The choice of eleven years was determined by data availability (same format of data) and the intention to level out extraordinary events.

Table 2-15: Number of killed and injured victims of aviation accidents, average of the years 1988 to 1999

Category of victims / Victim	**All**	Category of aircraft: Motorglider, glider	Helicopter	< 2.25 t MTOW*	2.25-5.7 t MTOW*	> 5.7 t MTOW*
All						
Accidents	53	11	14	3	2	23
Fatalities	30	5	7	13	-	5
Injuries	13	3	6	4	-	-
Accidents	53	11	14	3	2	23
Fatalities						
Members of Crew	12	4	3	5	0	0
Travellers	18	1	4	8	0	5
Third parties	0	0	0	0	0	0
Injuries						
Members of Crew	6	2	2	2	0	0
Travellers	6	1	3	2	0	0
Third parties	1	0	1	0	0	0

* MTOW = Maximum take-off weight

For the valuation of the accidents, additional information has been collected to assess the administrative costs and the level of the payments of insurance companies in the case of accidents.

2.6 Environmental costs

The cost category environmental costs contains seven different types:

– Air pollution,
– Global warming,
– Noise,
– Nature, landscape and further environmental effects, and
– Nuclear risk

The discussion of the input data below is divided according to these different costs categories.

2.6.1 Air Pollution

For quantifying the costs due to airborne pollutants the *Impact Pathway Approach*, the methodology developed in the ExternE project series[11] has been applied.[12] It comprises the steps:

- emission estimation,
- dispersion and chemical conversion modelling,
- calculation of physical impacts, and
- monetary valuation of these impacts.

For the calculation of the costs of direct emissions from vehicle operation emission inventories in spatial disaggregation are needed, i.e. a geo-coded data set for the different air pollutants. For each emission inventory, Europe-wide impacts are calculated and subtracted from impacts resulting from a reference inventory without these emissions. This procedure using a reference inventory is required, because of air chemistry processes where “background” emissions play an important role.

Besides the emission data, the distribution of the population over the space is the second central input for the calculations of the most important costs of air pollution, i.e. the health costs. For Switzerland, this information is available in form of a geo-coded hectare grid pattern with the number of buildings and people for each hectare. The figures stem from the census of population of 1990. They have been extrapolated to the year 1998 using average growth figures and assuming that the distribution over space remained constant.

In the case of Switzerland, link-based (i.e. geo-coded) information on the emissions of air pollutants has been prepared for **road transport**. The calculation based on a national transport model with more than 40 000 links representing the Swiss road network and on information for the different vehicle categories about the mileage, the technology of the vehicles, the fuel quality and the driving behaviour (see BUWAL, 2000). The table below shows the total sum of emissions (in tonnes / year) on these links for the air pollutants taken into account within UNITE.

Table 2-16: Emission of air pollutants of road transport, in t/a, 1998

Vehicle categories	CO2	NMVOC	NOx	SO2	PM10 Total	Particles
Motorcycles, bikes	167 228	3 097	465	21	36	0
Cars	9 897 463	26 392	30 029	1 324	2 529	328
Coaches	89 165	136	1 032	20	125	48
Buses	244 860	444	3 400	56	313	180
Light goods vehicles	989 631	2 024	3 627	163	424	236
Heavy goods vehicles	1 890 486	2 205	19 417	432	2 685	1 035
Total emissions	13 278 833	34 297	57 969	2 016	6 113	1 827

The last two columns show an important difference for the emissions of particles: Whereas

11 European Commission (1999) ExternE Externalities of Energy.

12 A short description of the model is contained in the annex of this Appendix Report.

the last column only contains the particles emitted through the exhaust pipe, the figures in the column “PM10 total” include the non-exhausted emissions of particles resulting from dust raising, abrasion of tyres etc. For the calculations with the ExternE model, the total PM10 emissions were taken into account.

For rail transport and urban public transport (tram and trolley bus only) less detailed information is available. In a first study dealing with this subject in Switzerland, it has been shown that also electrified rail transport – diesel traction is not relevant for Switzerland because it’s more or less only used for shunting[13] - causes a quite large amount of PM10 emissions. The use of the breaks, the whirling up of dust and the abrasion from the current collector and rails seem to result in more than 2 500 t of PM10 emitted per year (see BUWAL, 2001).[14] Because of the tentative character of the estimate and because there is no geo-coded information available about these emissions the calculations carried out with the ExternE model based solely on the information about the air pollutants emitted in the electricity production process. Table 2-17 summarises the main input data for the ExternE model.

Table 2-17: Energy consumption and electricity production mix for rail transport and urban public transport, 1998

	Energy cons.	**Electricity production mix, share in %**		
Transport mode	in 1'000 kWh	Hydro	Nuclear	Others
Rail transport	**2 153 327**	90.4%	9.4%	0.2%
Freight	878 852			
Passenger	1 274 475			
Urban public transport	**213 284**	56.3%	40.0%	3.7%
Tramway	124 823			
Trolley bus	88 461			

The electricity production mix differs between rail and urban public transport because the Swiss Federal Railways (SBB) have own hydroelectric power stations and therefore a very high share of “water”. The SBB mix is assumed to be representative for the rail sector as a whole. The reasons are:

– The situation of the other Swiss railway companies is partly comparable and they draw about 50% of their electricity need from the SBB,

– The SBB consumes more than 80% of total energy consumption of rail transport in Switzerland.

For urban public transport, the Swiss average production mix is assumed. For the valuation of the damages, estimates from European Commission (1999) for nuclear and hydro fuel cycles have been applied, after adaptation according to the UNITE valuation conventions given in Nellthorp et al. (2001).

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13 Converted into kWh, the diesel consumption in the rail sector of about 9’000 tonnes / year corresponds to less than 5% of total energy consumption.

14 However, it should be kept in mind that by far not the total sum of the particle emissions is harmful to human health. Those particles that are emitted outside of built-up areas and that are too heavy for large distance transmissions by wind are much less important.

In the case of **aviation**, detailed emissions data is available from the Swiss Federal Office for Civil Aviation.[15] The calculations of the costs of air pollution with the ExternE model were limited to air pollutants exhausted on the three national airports in Switzerland and to exhalation from fuelling (shaded cells in the table). The emissions are given in tonnes / year (t/a).

Table 2-18: Emissions from aviation in Switzerland, in t/a, 1998

Emission category	Fuel	CO	VOC	NOx	SO2	Pb
National airports	149 374.2	2 519.4	322.7	1 798.5	148.9	0.3
Regional airports	4 048.8	810.5	23.4	28.1	3.3	0.5
Airfields	2 196.6	1 069.6	27.2	9.2	1.1	0.8
Transit large airplanes	307 521.8	507.7	48.9	4 877.3	307.5	0.0
Transit small airplanes	8 319.0	1 617.8	11.0	73.6	5.1	2.9
Transit Helicopter	6 375.5	7.3	1.5	24.8	6.4	0.0
Emissions during fuelling	0.0	0.0	133.4	0.0	0.0	0.0
Fuel dumping	0.0	0.0	110.2	0.0	0.0	0.0
Total	477 835.7	6 532.3	678.4	6 811.5	472.3	4.6

Because no detailed information is available about the location of emissions from **fuel production** (comprising the processes extraction, transportation and refining), an average damage factor for emissions was used.

From the fuel use in t/a, the CO2 emissions can easily be calculated using a multiplying factor of 3.17 (source: BAZL (1999), section environment).

The tables above summarise the main input data to the ExternE model (see the annex of this Appendix Report).

2.6.2 Global Warming

The input data for the calculation of the costs of CO_2 are given in the tables above, partly immediately in form of CO_2 emission data. In the other cases, CO_2 emissions have been calculated from fuel consumption data (aviation) and from information on energy consumption and the electricity production mix (rail and urban public transport) shown in the tables 2-18 and 2-17 above. In the case of aviation, the CO_2 emissions on the three airports (LTO cycles) and the emissions of transit flights have been taken into account to represent the territoriality principle of the UNITE pilots accounts.

A shadow value of 20 € per tonne of CO_2 emitted is used for valuing CO_2 emissions, which reflects a European average cost estimate of meeting the Kyoto targets.

Looking further into the future, more stringent reductions than the Kyoto aims are assumed to be necessary to reach sustainability. Based on a reduction target of 50% in 2030 compared to

15 See BAZL (1999), Schadstoffemissionen und Treibstoffverbrauch des Zivilluftverkehrs in der Schweiz 1997. The 1997 figures are extrapolated to the year 1998 using the growth rates of starts/landings and number of transit flights as well as changes in the mix of aircrafts (lower emissions per "average aircraft").

1990, INFRAS/IWW (2000) use avoidance costs of 135 EUR per tonne of CO_2; however one could argue, that this reduction target is not or not yet accepted. Available damage cost figures would be substantially lower.

For a Swiss specific figure, several studies quantifying avoidance costs of a reduction of greenhouse gas emissions in different sectors are available. One specific study (INFRAS, 1992) estimated the costs of several measures to reach CO_2 targets with a bottom up approach and compared the results with a top down approach, where rent losses due to a reduction of a target oriented CO_2 tax were estimated. The following table shows the results.

Table 2-19: Greenhouse gas reduction targets and avoidance cost estimates for Switzerland

Target, time horizon	Avoidance costs in € / tonne of CO_2	
	Top down	bottom up
-20% 1990-2005	140	80
-20% 1990-2025	30	30
-40% 1990-2025	75	30

These results had to be updated to 1998 and re-estimated for the new Swiss targets. According to the CO_2 law, petrol and diesel consumption has to be reduced by 8% between 1990 and 2010. Since fuel consumption could not be stabilised between 1990 and 1998 (even increased by 5%), the CO_2 costs for the remaining years until 2010 will increase. Thus, a more recent study (Maibach et al., 1999) concluded a higher avoidance cost of € 60 to € 100. Thus we will use an average of € 80 per tonne of CO_2 for a Swiss sensitivity analysis.

2.6.3 Noise

The quality of the input data for the calculations of the costs due to noise exposure is rather low in the case of **road transport**. The available "official" information on the number of flats exposed to different noise levels is published in a study carried out at the beginning of the nineties on behalf of the Dienst für Gesamtverkehrsfragen GVF (Service for Transport Studies).[16] Additional information including a differentiation of the noise exposure between day and night can be found in Müller-Wenk (1999) for the year 1995. The results of both studies are summarised in table 2-20. The calculations of the noise costs started from the figures of Müller-Wenk.

There is an intention of the responsible Federal Office for Spatial Development to launch a comprehensive project to obtain detailed data about the current noise exposure situation in Switzerland. Against this background, the calculations of the external noise carried out within UNITE based on the old input data costs have to be considered as rather tentative.

16 Infraconsult (1992), Soziale Kosten des Verkehrslärms in der Schweiz. Average figures for the number of inhabitants per flat have been used to derive the number of people exposed to transport noise.

Table 2-20: Population exposed to different categories of road transport noise levels, early/mid-nineties

Noise category	GVF-Study Flats	GVF-Study Persons	Müller-Wenk Persons: Day	Müller-Wenk Persons: Night
55-59 dB(A)	309 060	699 114	1 567 280	584 168
60-64 dB(A)	252 530	571 239	954 616	206 596
65-69 dB(A)	213 340	482 589	463 060	21 372
70-74 dB(A)	84 480	191 099	92 612	-
75+ dB(A)	11 330	25 629	7 124	-

In the case of rail transport the situation is comparable. Available data is published in the GVF study mentioned above. Furthermore, the SBB worked out an update of these figures for the year 1995. Table 2-21 summarises the available input data for rail transport.

Table 2-21: Population exposed to different categories of rail transport noise levels, early/mid-nineties

Noise category	GVF-Study Flats	GVF-Study Persons	Data of SBB Persons
55-59 dB(A)	51 760	114 715	100 000
60-64 dB(A)	42 280	93 705	100 000
65-69 dB(A)	35 750	79 232	90 000
70-74 dB(A)	14 140	31 338	45 000
75+ dB(A)	1 900	4 211	17 000

The situation for **aviation** is much better: For this mode, detailed calculations of the share of population exposed to air transport noise have been carried out especially for UNITE by the Eidgenössische Materialprüfungszentrale EMPA for the three national airports of Switzerland. Therefore, the figures given in table 2-22 for air transport are of a much higher quality than the figures for rail and road transport.

Table 2-22: Population exposed to different categories of air transport noise levels, 1998

Noise category	Persons
55-59 dB(A)	112 347
60-64 dB(A)	71 251
65-69 dB(A)	16 711
70-74 dB(A)	3 277
75+ dB(A)	6

As in the case of the costs of air pollution, the ExternE model has been used for the valuation of the adverse effect of noise exposure. Noise costs were quantified for a number of health impacts calculated with new exposure-response functions. In addition, amenity losses were estimated using a Hedonic Pricing approach, i.e. information about reduced values of real estates along/near noisy transport infrastructure links/areas was used for the calculations. The methodology for quantifying noise costs was extended to the calculation of physical impacts. Costs for the following endpoints were quantified:

- Myocardial infarction (fatal, non-fatal)
- Angina pectoris
- Hypertension
- Subjective sleep quality

Table 2-23: Valuation of health impacts due to noise exposure

Endpoint	Value	Unit
Myocard infarction (fatal, 7 years of life lost)	94 902	€ per YOLL
Myocard infarction (non-fatal)	800	€ per cardiology-related inpatient day
Myocard infarction (non-fatal)	117	opportunity costs due to absenteeism from work in € per day
Myocard infarction	16 905	€ per case to avoid morbidity (disutility)
Angina pectoris	800	€ per cardiology-related inpatient day
Angina pectoris	117	opportunity costs due to absenteeism from work per day
Angina pectoris	266	€ per day to avoid morbidity (disutility)
Hypertension	417	€ per inpatient day
Subjective sleep quality (COI)	264	€ per year
Subjective sleep quality (WTP)	432	€ per year

COI = Cost of illness. - WTP = Willingness-to-pay. - YOLL = Year of life lost.
Source: Metroeconomica (2001) and own calculations

A large number of Hedonic Pricing studies has been conducted giving NSDI values (Noise Sensitivity Depreciation Index – the value of the percentage change in price arising from a unit increase in noise) ranging from 0.08% to 2.22% for road traffic noise. In the latest Hedonic Pricing study for Switzerland carried out with high quality data of the Zurich Cantonal Bank, a value of 0.66% is estimated (see Ecoplan, 2000). In the same study a Swiss average value is derived from all relevant studies worked out in Switzerland. The value of 0.9% is similar to the average derived from European studies and is used for the calculations. The average rent used for the calculations is estimated at 617 EUR / month (see Ecoplan, 1998).

In the ExternE model, a bonus of 5 dB(A) is applied for railways.

2.6.4 Nature, Landscape and Further Environmental Effects

As a consequence of the approach chosen (see section 3.5.4 on methodology) the input data for nature, landscape and further environmental effects such as soil and water pollution is basically mode, length and type of infrastructure (network data), of which the sealed and impaired area derives. Data quality for the sealed areas is generally good. For the impaired soil areas, assumptions have to be made for the width of these areas along each side of the infrastructure network. The repair costs (for unsealing, decontamination of soils) are taken from

Bickel et al. (2000). For the calculation of the barrier effect of built infrastructure, a new approach is chosen for Switzerland (see section 3.5.4). The following table summarises input data and data quality for nature, landscape and further environmental effects.

Table 2-24: Input data and data quality for nature, landscape and further environmental effects

	Input data	Level of disaggregation	Quality of data, level of uncertainty
Road	a) Network-data (National roads = Motorways, cantonal roads = Inter-urban/Rural roads), tunnels	By type of road only (considering roughly tunnels/bridges	High quality for motorways Tunnels for national roads/Motorways only
	b) traffic performance data (vehicle-km)	Type of vehicle	
Rail	a) Network-data (length, type of railtrack: high-speed/ conventional), Tunnels	By type of railtrack	Data for 1997 Tunnel-length for entire network only (for 2005 without the NEAT project)
	b) performance data (train-km)	Long-distance-, local- and freight traffic	Data for 1997
Aviation	Sealed area of airports	International, regional airports and sealed airstrips	Detailed estimations of sealed areas for Zurich Unique Airport (1950, 1996/98, 2005), Geneva-Cointrin (1998) Basle-Mulhouse (1990 = area 1998. and 2001=area 2005). The number of regional airports and airstrips is known (1998), the sealed area is estimated. Rough estimation of sealed area for the base year 1950 and for 2005
General	a) Cost values	Habitat loss/barrier effect, unsealing, soil decontamination, ground water	

2.6.5 Nuclear Risk

For the calculation of the nuclar risk the nuclear power consumption of the public transport systems has to be known. Table 2-17 in section 2.6.1 shows the energy consumption and the electricity production mix for rail and urban public (trolley buses and tramways) transport modes. Other parameters for the calculation of the shadow price of a nuclear power unit to be used for the risk calculation are given in Bickel et al. (2000). The following table summarises the input data needed for the calculation of nuclear risk costs and data quality.

Table 2-25: Input data and data quality for the calculation of nuclear risk costs

	Input data	Level of disaggregation	Quality of data, level of uncertainty
Road	a) Electricity consumption of trolley buses and trams	Data for trolley buses and trams separately	Data for 1997 (and 1996)
	b) Nuclear share of the Swiss power production mix	Overall Swiss mix	Assumption trolley buses and tramways consume the average Swiss electricity mix
Rail	a) Electricity consumption of rail	Average yearly consumption based on monthly figures also considering import/export rata Power consumption includes use for infrastructure, lights, etc.	SBB and other private railway companies with minor electricity consumption are considered separately Assumption: all these railway companies consume the SBB electricity mix
	b) Nuclear share of the SBB power production mix	Monthly consumption figures are considering rail-specific electricity mix of consumed (not produced) electricity	
General	a) Shadow price for nuclear power risk costs	Calculation for Switzerland according to Accounts approach following Zweifel and Umbricht (2000)	Assumptions: max. damage costs at 100 billion CHF; average cost internalisation (insurance) of nuclear power at plant level = 2%

2.7 Taxes, Charges and Subsidies

Taxes, charges and subsidies are calculated and estimated within the respective infrastructure or supplier operating costs sections of each mode. The following table presents the main data sources which are basically the same as data sources for infrastructure and supplier operating costs.

Table 2-26: Input data and data quality for the calculation of taxes, charges and subsidies

	Input data	level of disaggregation	Quality of data, level of uncertainty
Road	Infrastructure cost accounts (revenue part), based on Swiss national road accounts (Swiss Federal Statistical Office)	By vehicle category and by type of charge/tax	Very high (periodic data)
Rail	Infrastructure accounts Transport accounts	Infrastructure charges subsidies Charges, subsidies for public service obligations	Very high (periodic data)
Road based PT	National accounts	Revenues Subsidies	High (periodic data), for 1998 only provisional data available
Aviation	Business accounts of airports	Type of revenue	Very high (periodic data)
Ports	Business accounts (ports)	Type of revenue	Very high (periodic data)

3 Methodological Issues

The methodology how to proceed within the different cost fields to assess the transport costs is described in detail in Link et al. (2000)[17] and very briefly summarised in section 1.2 of this Appendix Report. Against this background, we renounce repeating the extensive methodological discussion but concentrate on the following issues:

– deviations from the general methodology developed in Link et al. (2000) and/or specific methodological issues that should be discussed in more detail within UNITE,

– the backcast and forecast methodology applied to estimate the cost figures for the years 1996 and 2005 respectively.

3.1 Infrastructure Costs

Generally, we carried out the methodological working steps for the calculation of infrastructure costs which correspond to Link et al. (2000) (see figure 3-1 below).

The applied methodology differs for all modes from the Link et al. (2000) in the following points :

– Aggregation level: Depreciation and interests for a cost category are shown overall, not further differentiated,

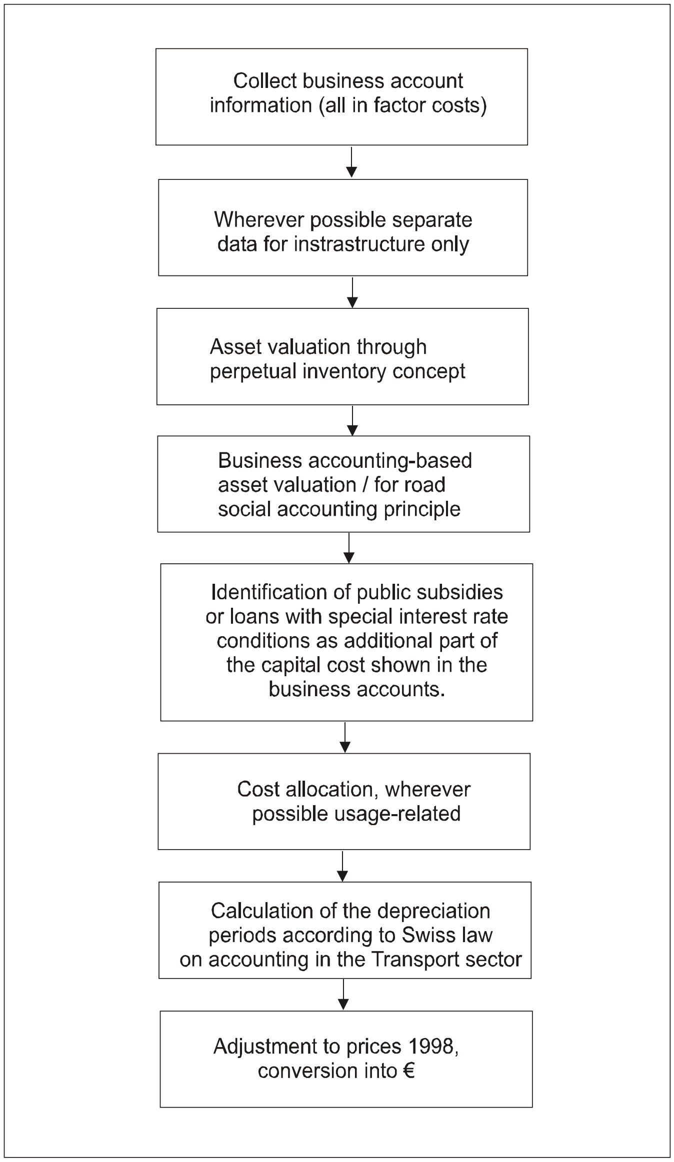
– Cost structure: No differentiation between fixed and variable costs because we had not enough information for a reliable and accurate split,

– Data availability: For road based public transport and airports it is not possible to separate costs, asset values (and depreciation) or the revenues of flight-related infrastructure from the total (and from the non-flight-related part).

Asset valuation not at constant prices but at purchase costs (and consequently use of nominal instead of real interest rates).

[17] Additional detailed information for each cost category is contained in internal annexes to Link et al (2000) (Interim Reports for each cost category).

Table 3-1: Overview of the procedure for calculating infrastructure costs per transport mode



3.1.1 Road

Base Year: Basic data stems from the Swiss road account of the BFS. This information is based on expenditure for roads in Switzerland. The investments are activated each year. The asset valuation is calculated by a perpetual inventory concept. The costs include building costs, maintenance costs, traffic control, administration, signalisation and capital costs. Depreciations and imputed interest rates on the cumulated investments add up to the capital costs.

Backcast methodology: For 1996, no backcast was necessary, because the information was available for 1996 in the same way as it was for 1998.

Forecast methodology: The starting point of the forecast for 2005 is the results for 1998. Firstly, a forecast for the investment and maintenance costs and all the other cost categories for all the years 1999-2005 has to be done. This forecast is based on the opinion of experts from the Swiss Government for all road types. The asset valuation is then again calculated by perpetual inventory concept and the relevant costs derived from this value. The next step seeks to allocate the forecast costs user-related to the 30 different vehicle categories. For this the mileage of all vehicle categories has to be forecast. For that we rely on a study from the Swiss Federal Office of Transport (GVF, 1995) and an up-to-date national study covering the same issue (HBEFA, 1999). In a first step, these figures are used for cost allocation. The forecast of these figures does not take into account that in 2005 the weight limit for lorries has risen to 40 tonnes. To introduce this in our account we rely on a forecast from INFRAS (2000). In the end we get the expected mileage for the 30 vehicle categories and can do the cost allocation. The basis for the forecast of the revenues is from INFRAS (2000). In order to split up the forecast revenues into the different categories we need a forecast for revenues from the new distance-dependent heavy vehicle fee (GVF, 1999) that replaces the flat heavy vehicle fee. At the end, the structure of the data file 2005 is exactly the same as 1998 and reflects the structural changes for the new weight limit of 40 tonnes (before 28 tonnes) and the introduction of the “distance and weight dependent heavy vehicle fee“.

3.1.2 Rail

Base Year: Data sources are the profit and loss accounts divided into the categories infrastructure, transportation of passengers and transportation of freight as well as the detailed asset and depreciation account of all railway companies. Based on this information, we build an entire new rail account showing costs and revenues for rail infrastructure, passenger and freight (the official rail account so far shows only figures for railway overall). In a next step, we deduct the capital costs shown in the profit and loss account and add the economically correct capital costs. These are calculated out of the analysis of all the asset and depreciation accounts. This results in a value of total depreciation and total asset value. The first figure can be used directly in the account, the latter provides the basis for calculating imputed interests on the total of the fixed capital (incl. opportunity costs). The last step is the compilation of hidden subsidies (capital investments paid from public authorities, not activated in the asset and depreciation account of the railway companies) and the calculation of depreciation and interest from this part. By adding these figures to the total of depreciation and interests from above the new account is completed for infrastructure rail.[18]

Backcast methodology: For 1996 we were unable to do the same, because 1998 was the first year for which profit and loss accounts divided into the categories infrastructure, transportation of passengers and transportation of freight were available. In all the earlier years the railway accounts provided only an overview on infrastructure and operating together. For the backcast we go back to this aggregated railway account and cast back from our new rail account 1998 with factors stemming from the change in the aggregated railway account between 1998 and 1996. The methodology used is the same as for supplier operating costs for railways. As there were no major infrastructure investments, no additional correction of depreciation was necessary.

Forecast methodology: The basic information for the forecast of the railway account is the mid-term plan of the Swiss Federal Railway Company, by far the most important of all rail-

18 Methodology described in detail in INFRAS (2000).

way suppliers in Switzerland. This plan shows the expected development of costs and revenues in the following years separated into infrastructure and operating costs. The methodology is similar to the one for the backcast above. We use the predicted change in cost and revenues in the category infrastructure and utilise these factors to adjust the 1998 data basis to the 2005 account. Infrastructure investments have not to been taken into account separately, as they are already included in the mid-term plan figures. What has additionally to be considered is the change in imputed interest. From the figures of the Swiss Federal Railway Company the forecast is made with assuming the same percental change for all other railway companies as well. Other railway companies will make major infrastructure investments in the time period between 1998-2005. We need the information of the total investment sum and the time horizon in order to add these investments (paid by public authorities) to the asset and depreciation account. Additionally, we assumed for the forecast period a slightly lower labour intensity (i.e. higher productivity). The new alpine tunnels (NEAT) have not been included in the 2005 account. These investments are processed in separate special institutional entities, and it has not been defined yet who in the end will operate and own the new infrastructure. The opening date will be after 2005.

3.1.3 Aviation[19]

Base Year: The basic information stems from the business accounts (annual reports) from the three national airports Zurich, Geneva, Basle-Mulhouse and from the air traffic control company Skyguide which is responsible for air traffic control all over Switzerland. It is not possible to separate the information from the annual reports into flight related infrastructure and non-flight related infrastructure (on the cost side it is totally impossible, on the revenue side some parts would be applicable). Therefore the whole profit and loss account is used for this pilot account. The second information we need for the calculation of total infrastructure cost is hidden subsidies for the airports. We had intensive contacts with the Swiss Federal Office of Civil Aviation and obtained all the figures on all subsidies and loans at a reduced interest rate dating back to World War II. Since 1994 no subsidies or loans at reduced interest rates have been provided. On the cantonal level no such hidden subsidies can be found at all. In order to calculate the additional capital costs from the hidden subsidies we first took the subsidies and deducted then the part relevant for the airlines (Swissair) and for the airport (in order to avoid double counting). From this reduced amount we calculated the lost interest payments on these subsidies (incl. compounded interests) until 1998 and added them to the total amount of subsidies. From this amount the additional imputed interest can be derived. Until 1994 the state provided loans at reduced interest rates to the airports. We know the sums, the time of the issue of the loans and the time when they are due for payment. The methodology to find the hidden subsidies (lost interest payments of the public authorities) is similar to the subsidies. However, we take the difference between the reduced interest rate and the market interest rate and sum-up. From the total sum, the imputed interest from the loans can be calculated and added to the other capital costs (interests). Because the airports have to sustain their infrastructure themselves, one can assume that depreciation is correctly calculated.

19 For this part, an in-depth-study for Switzerland has been initiated in order to analyse the valuation of infrastructure costs and the cost allocation more accurately. The results will be available by the end of 2001 and will be included in the final report.

Backcast methodology: For 1996 the methodology is almost the same. For Geneva and for Skyguide no annual reports were available. Exclusively for them we had to make assumptions about growth between 1996 and 1998 based on benchmarking.

Forecast methodology: The methodology for the 2005 forecast is similar to the 1998 account for all three airports and the Swiss air traffic control. For Geneva and Basle-Mulhouse we assumed annual trend growth of the past five years. This also fits very well with the forecasts from the Federal Office for Civil Aviation (ITA, 1999). For the forecast of the costs and revenues from the Swiss air traffic control we used the forecast growth of passengers (corresponding with a growing number of aeroplanes) in Switzerland in ITA (1999). For Zurich airport we made a two step forecast: First we made a forecast using the former capital costs. For Zurich we took the growth rate for the revenues according to the forecasts for Zurich in ITA (1999). For the costs we assumed a growth 1.5 percentage points lower than the growth of the revenues (corresponds with development 1996-1998). This assumption is rather conservative. In the past years the difference in the growth rates between costs and revenues was higher. In a second step we took into account that the fifth extension stage (all financed without hidden subsidies) of the airport Zurich will lead to significantly higher depreciation and interest payments. From the total amount of investment we deducted the non-relevant part (train station, airline (Swissair)). The remaining total amount (about € 1.3 billion) was equally divided over the duration of the construction 1996-2005. Based on this we made a separate asset and depreciation account for this fifth extension stage. The interest rate has to be added additionally to the result in the first step based on the book value and the depreciation on the accumulated investment costs. We assumed a depreciation rate of 2.5% which represents a lifetime of 40 years.

3.1.4 Inland Waterways

Base Year: Basic information stems from the annual reports from the two ports in Basle (Rhine). For 1998 both annual reports and the asset and depreciation account of one port were available. Additional information came from two experts of the cantonal administration. According to their information the ports did not receive any subsidies or loans at a reduced interest rate from the Cantons. The state accorded subsidies for investments on the port area, but this was for a railway station and may not be included in this account. For the asset value of one port (missing asset and depreciation account), we assume that this port has the same structure of assets as the other Rhine port and therefore the same relation between depreciation and asset value.

Backcast methodology: For one port we have the same information as for 1998. For the other port we start from the figures 1998 and assume a real growth of 3% for all cost categories and revenues. An exception is the depreciation which we know from the cantonal expert for both ports in detail.

Forecast methodology: For the forecast 2005 we had no information from experts or corresponding studies available. We made an analysis of the developments between 1998 and 2000 (annual reports) and extrapolated the figures with this annual change, tried to evaluate special effects between 1998 and 2000 and used an adjusted growth rate for the final extrapolation. The ports use an unusual depreciation method: All investments are totally depreciated in the first year. In order to show the economic cost, we assumed that the three years considered are representative for the aspect of annual investments. We took an average of the three figures as average annual depreciation in all three years. Because of the infrastructure enlargements in

2000, the depreciation for 2005 was additionally adjusted with a growth factor calculated from the increase in the running costs due to the higher turnover after the enlargements.

3.2 Supplier Operating Costs

3.2.1 Rail

The BFS provides annual data on costs and revenues of all Swiss railways where aggregated running costs (among other categories such as depreciation, interest, personnel costs, etc.) are accounted. In order to disaggregate this cost category into the more detailed sub-categories, as required for the pilot accounts, the sectoral account (for details of the generation of sectoral account see chapter 3.2.1) for the Swiss Federal Railways SBB (only available for 2000) is used. It provides the key for the cost allocation, after being reduced to the two divisions passenger and freight.
The following list indicates the available cost categories:

– Material, goods, services (includes consumables, fuel costs, maintenance, cleaning and servicing),
– Personnel,
– Other running costs (e.g. tenure and rental, fees, compensation for expenses or employees, insurances and compensation),
– Depreciation,
– Interest,
– non-deductible VAT,
– Cross-sectoral costs (inter-company invoicing),
– Special costs.

Revenues (as an aggregate) and subsidies are also displayed.

Backcast methodology: Since the SBB 1996 annual report gives reason to assume that there is no significant change in the allocation of costs and revenues, the same distribution key was used to subdivide the running costs of Swiss railways of 1996 (Swiss railway accounts supplied by the BFS).

Forecast methodology: The SBB mid term plan provides projections on the future development of costs and revenues for the Federal Railways (SBB) up to the year 2005. The annual growth rates are used to estimate running costs, depreciation and interest, revenues and subsidies. Based on these figures, running costs are then subdivided again in the sub-categories mentioned above, using the same key as in the reference year 1998.

3.2.2 Road Based Public Transport

To calculate supplier operating costs in urban and regional public transport, official public transport statistics could be used. Supplier operating costs and revenues have been calculated simultaneously, because official statistics contain cost as well as revenue and subsidisation figures.

Base Year 1998: Supplier operating costs of urban and regional public transport services are directly taken out from the official statistics (BFS, 2001). However, the data set is provisional and shows several void records for approximately 5% of mainly smaller regional public transport companies. Therefore, missing records have been completed with 1997 data. The data set for urban public transport companies was complete. Since official public transport statistics are based on business accounts, costs are already expressed at factor costs.

The following list shows the allocation categories of the Swiss pilot accounts:

– Material, goods, services,
– Personnel,
– Other running costs,
– Depreciation,
– Interest.

Backcast methodology: There was no specific backcasting methodology necessary due to the fact that the official data-set could be used (BFS, 1997, 1998, 2001).

Forecast methodology: Future supplier operating costs are estimated in a two-step approach:

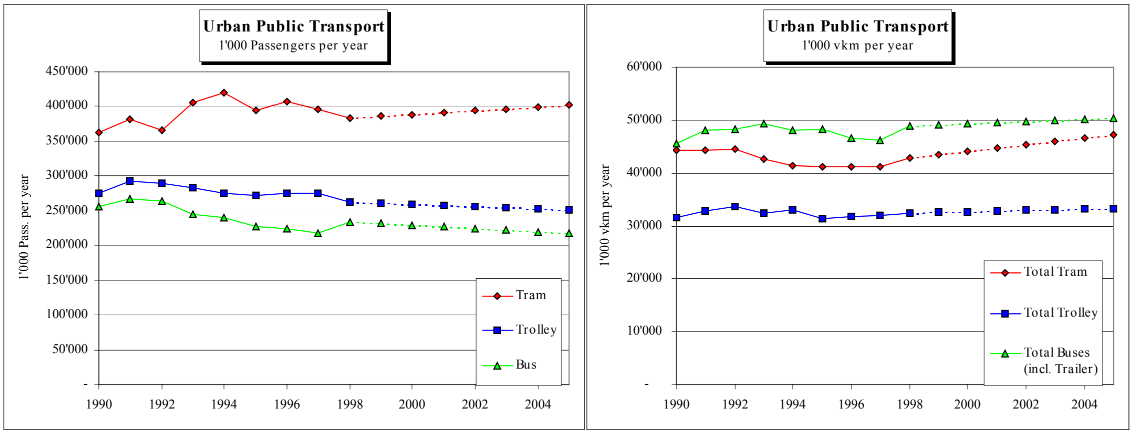
1. Trend-extrapolation of the relevant transport figures (i.e. mileage of rolling stock, number of transported passengers)

2. Analysis of the development of the most important cost drivers:
   - total costs per vehicle-km,
   - total costs per passenger,
   - personnel cost per vkm of railcars, trolley buses and buses.

Official public transport statistics shows in the period from 1990 till 1998 a decline of passengers for some modes. It's not completely certain that behind these published figures a real reduction of demand had taken place or if a change of passenger counting system lead to these results. Before 1995, most transport companies estimated the number of their passengers, using sales figures of tickets and long term passes. Especially for monthly and yearly public transport passes, the number of trips is appraised on assumed trips per ticket. Since electronic passenger counting systems turned up, many companies detected that the real number of trips with long term public transport passes is significantly lower than estimated. Therefore, transport statistics should be regarded sceptically concerning passenger figures.

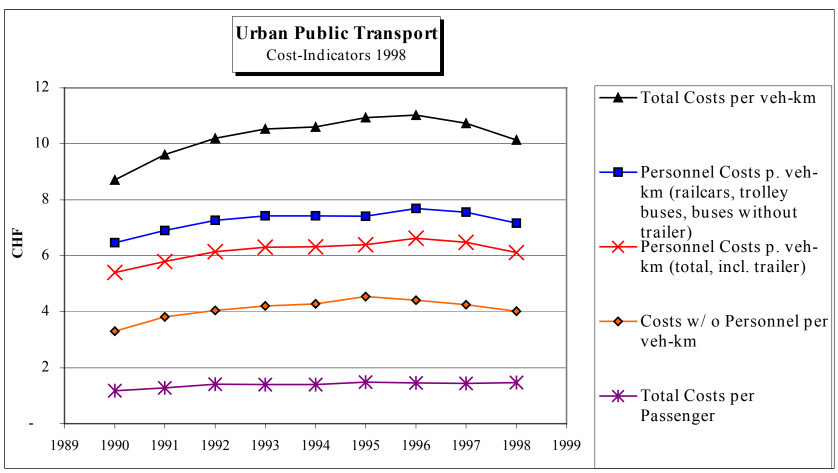
The following figures show the development of passengers and mileage of rolling stock in the past and the derived future values for urban public transport.

Table 3-2: Forecast of passengers and vehicle in urban public transport in Switzerland (BFS 2001, values until 1998), own forecast after 1998



Based on the extrapolated future vehicle-km, future costs are estimated by 1998 cost indicators.

Table 3-3: Cost Indicators in urban public transport 1990-1998 (nominal prices, BFS (1997), BFS (1998), BFS (2001))



In 1996, a new law for railways and public transport was introduced which enabled competition in the former highly regulated public transport market. Since services could be procured in a tendering procedure, efficiency of most public transport companies improved significantly. The figure above illustrates the effect of the first liberalisation steps which result in the effect that cost indicators decrease from 1995 onwards.

Future supplier operating costs are estimated hereby based on 1998 cost indicators. Although e.g. total cost per vkm seems to decrease rapidly since 1996, an ongoing decrease in the same extent is not very likely, because therefore additional steps towards liberalisation would be necessary. Furthermore, because of the dry labour market in Switzerland, personnel costs which contribute to over 50% of total supplier operating costs in public transport, have since 1998 again slightly risen . Overall, the assumption of stable supplier operating costs seems to be justified.

The same forecasting methodology is used for regional public transport services.

3.3 Congestion Costs

3.3.1 Road

The methodological approach for congestion costs in road transport follows the methodology which was developed in the INFRAS study on congestion costs of road transport for Switzerland in 1998 (ASTRA, 1998). Base year of that study is 1995. Therefore, all available new data sources for the period 1996-1998 have been used to update the 1998 study. The study embraces several basic approaches for the estimation of congestion costs on the Swiss road network:

– Total road network:
  - Overall estimates concerning time delays based on differences between average travel speeds in peak-hours versus normal traffic conditions,
  - Results of a recent study within the Canton of Zug which measured directly travel time differences peak – off-peak of a random sample of drivers.
– Motorways and major inter-urban roads:
  - Reports of traffic jams by radio stations and police offices,
  - Model calculations based on traffic speed-flow relationships.
– Urban trunk and arterial roads:
  - Model calculations for towns and cites (on the basis of two case studies for Zurich and Bern).

Basic values: The vehicle occupancy per travel purpose is derived from BFS (1996).

Table 3-4: Vehicle occupancy by travel purpose (BFS, 1996)

Vehicle occupancy	Business	Commuting	Leisure	
Vehicle occupancy weekdays	1.3	1.2	1.89	
Vehicle occupancy weekends	1.3	1.2	2.07	
Shares per travel purpose	**Business**	**Commuting**	**Leisure**	**Average**
Motorway/Inter-urban road weekdays	20%	33%	47%	1.56
Motorway/Inter-urban road weekends	3%	6%	91%	2.00
Agglomerations peak-hours	15%	65%	20%	1.38

Overall estimations: A primary rough estimate of congestion costs is based on speed differences in peak hours versus off-peak hours. Speed differences for motorways, interurban/rural and urban/local roads are taken out of a recent study win the Canton of Zug (INFRAS 2001; not yet published), where for the first time speed and speed-differences have been measured directly with a random sample of drivers. Average speed on inter-urban roads and the share of mileage which is subject to disturbed traffic conditions during peak-hours are taken out of ASTRA (1998).

Table 3-5: Share of vkm under disturbed traffic conditions (share of disturbed traffic taken out from ASTRA (1998), mileage taken out of HBEFA (1999))

[mill. vkm]	1996		1998		2005	
	total	peak-hours	total	peak-hours	total	peak-hours
Motorways	13 667	3 143	14 162	3 257	16 055	3 693
Inter-urban/Rural roads	17 182	3 952	17 805	4 095	18 616	4 282
Urban/Local Roads	15 042	3 460	15 587	3 585	16 041	3 689

There is no additional information available on future speed differences during peak-hours, so for a first-best estimation the same speed differences are used for the forecast calculation for 2005.

Table 3-6: Average speed and speed differences during peak and off-peak hours (ASTRA (1998); INFRAS (2001))

	Average speed off-peak hours [kph]	**Speed difference** peak hours [kph]	**Vehicle-delay-hours due to disturbed traffic during peak hours** [mill. v-hours]		
			1996	**1998**	**2005**
Motorways	95.3	10.1	3.9	4.1	4.6
Inter-urban/Rural roads	70.0	6.7	4.3	4.5	4.7
Urban/Local Roads	36.0	5.1	15.9	16.4	16.9
Total			**24.1**	**25.0**	**26.2**

Calculations based on reported traffic jams (motorways, major inter-urban roads): The Swiss Federal Roads Office (ASTRA) provides a yearly survey on reported traffic jams on the national main road network. Since mid 1996, traffic jam reports (mainly from radio stations and police authorities) have been collected by the TCS (Touring Club Schweiz) and passed on to the ASTRA. However, only major traffic hold-ups are reported and the survey did not provide any information on the length of traffic jams.

An in-depth analysis of the 1995 traffic jam reports which contains basic information on the length of traffic jams allows the calculation of vehicle congestion-hours for Cars, HGV and LGV. However, the methodological change in mid 1996 leads to lower total congestion-hours, because only major traffic hold-ups have been reported since then. Beyond that, no information on the length of traffic jams is collected any more. Therefore the 1995 congestion structure is used to estimate the 1996 and 1998 values of vehicle congestion hours.

Table 3-7: Reported traffic jams on the Swiss motorway network and resulting vehicle-congestion-hours (ASTRA (1998); ASTRA (1999))

Reported traffic jams [congestion-hours]	**1995**	**1996**	**1998**
Congestion	1 292	1 433	1 996
Accidents	1 101	1 474	1 865
Road works	747	820	1 418
Other causes	174	255	361
Total	**3 314**	**3 982**	**5 640**
v-hours in congestion	2 529 000	3 039 000	4 307 000

Model calculations motorways: From studies of models based on speed-flow relationships (see figure below) and traffic models, the capacity-related time losses on Switzerland's motorway and major inter-urban road network was estimated (see details on methodology in ASTRA (1998)).

Table 3-8: Speed-flow relationships for Cars and HGV on motorways (Type 1: motorway, speed-limit 120 kph, 2 lanes per direction, Type 2: motorway, speed-limit 100 kp, 2 lanes per direction, Type 3: motorway, speed-limit 120 kph, 3 lanes per direction, Type 4: inter-urban road, 1 lane per direction, (ASTRA, 1998)

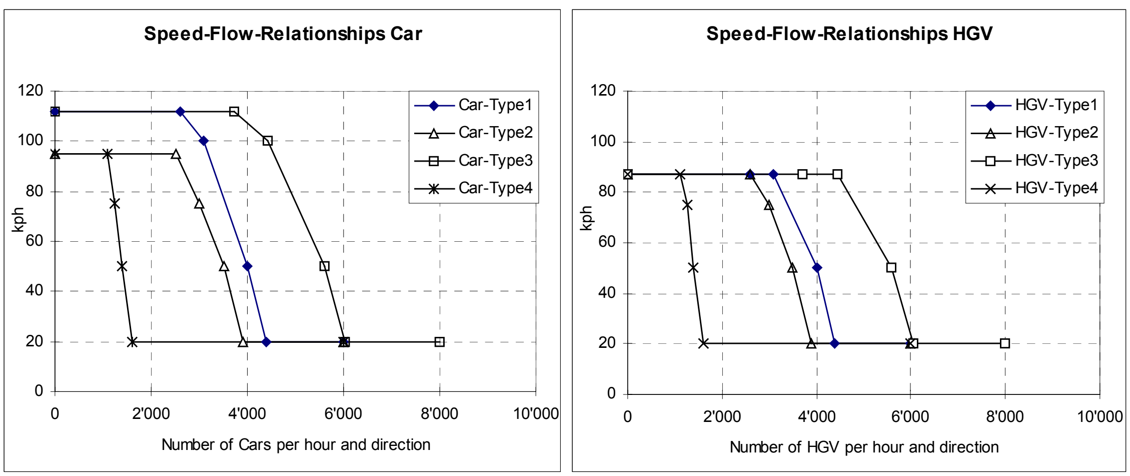
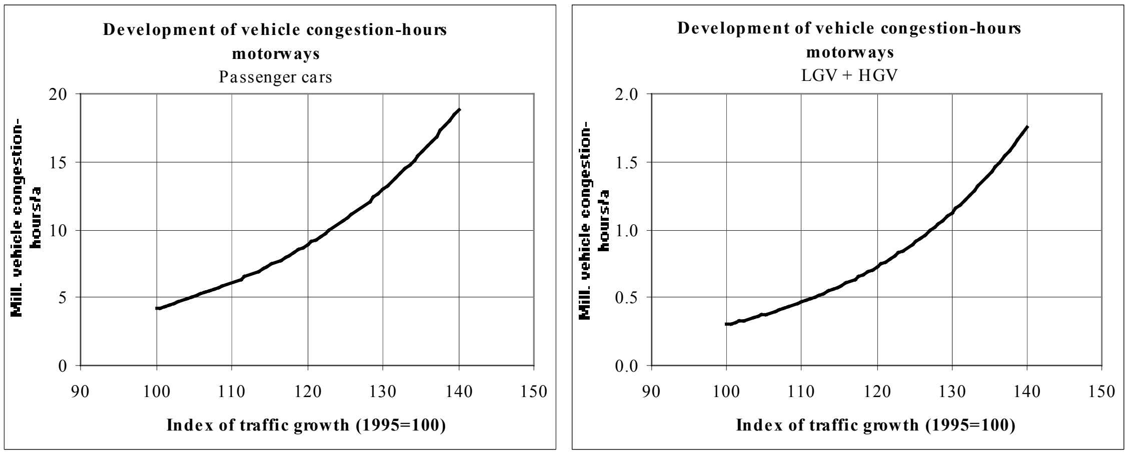


Table 3-9: Development of vehicle congestion-hours on the Swiss motorway and major inter-urban road network (basis of the model calculation: 1995; ASTRA, (1998))



To obtain the respective number of congestion hours for 1996, 1998 and 2005, the growth rates for cars, LGV and HGV are taken from BUWAL (2000) and the 'INFRAS-Handbook of Emission Factors in Road Transport' (HBEFA, 1999) which contains the official road traffic forecast figures up to 2020 (see also table 2-2).

Table 3-10: Growth rates (vkm) for road transport and resulting congestion-hours on the Swiss motorway and major inter-urban road network (BUWAL (2000); HBEFA (1999))

	Growth rates mileage (base year 1995)			**Vehicle-congestion hours** [mill. v-hours]		
	Cars	**HGV**	**LGV**	**Cars**	**HGV**	**LGV**
1996	0.7%	3.4%	2.8%	4.282	0.181	0.162
1998	4.3%	12.3%	10.1%	4.913	0.261	0.231
2005	18.2%	15.0%	40.7%	8.311	0.473	0.521

Model calculations for urban and suburban areas: This model-based approach estimates extended travel time due to disturbed traffic in cities and agglomerations throughout Switzerland. This approach is described in detail in ASTRA (1998). It is mainly based on two case studies in Bern and Zurich, where travel time differences between peak and off-peak-hours of cars crossing the city perimeter during the morning and evening peak have been measured. The number of cars entering and leaving cities and the surrounding area during peak-hours was more or less stable within the last decade due to the fact that traffic control systems work as gatekeepers which only allow a specific amount of cars per time period to enter the city (see Stadtpolizei Zürich, 1998 for details). As a consequence, traffic in cities only seldom suffers from a complete traffic break-down even during the peak-hours but more likely from stop and go and disturbed traffic conditions. In contrast, congestion on access roads (motorways and major inter-urban roads) rises significantly during that period. To forecast 2005 values, a slight increase of the population in urban areas has been assumed which leads to a proportional increase of the number of cars .

A more detailed analysis using a traffic model in the city of Bern also shows that approx. 50% of the total time loss during peak-hours consists of small delays of 5 minutes or less. In a sensitivity analysis we subtract these small delays from the total delays which results in approx. 50% lower vehicle delay-hours.

Apart from the two case studies in Zurich and Bern, there is no data on congested or disturbed traffic available for other Swiss cities. Therefore ASTRA (1998) suggests an extrapolation methodology for all 56 cities in Switzerland with more than 15 000 inhabitants, which estimates estimating the number of trips as well as the extra delays for cars crossing the city border during peak-hours (see details in ASTRA 1998).

The results of the model calculations are as follows:

Table 3-11: Total delays in cities and suburban areas Switzerland

	Unit	1996	1998	2005
Total delays	v-hours	18 400 000	18 200 000	18 500 000
of which small delays (< 5 min.)	v-hours	9 200 000	9 100 000	9 300 000

Additional fuel costs: Additional fuel costs are calculated with a consumption and emission software (Handbook of Emission Factors in Road Transport (HBEFA, 1999). Excess fuel consumption of a driving cycle which corresponds to a typical stop and go situation (average speed: 10 kph) is calculated and compared to normal traffic conditions. Fuel prices in 1996 and 1998 are taken from different publications of the Touring Club Switzerland (TCS). The resulting costs refer to one delay/congestion-hour.

Table 3-12: Additional fuel costs due to congestion (HBEFA, 1999)

	Car (gasoline)	**HGV** (diesel)	**LGV** (gasoline)
Excess fuel consumption [g/cong.-hour]]	600	5 200	1 000
Fuel price 1996 [CHF/l]	1.15	1.19	1.15
Fuel price 1998 [CHF/l]	1.21	1.27	1.21
Fuel Costs 1996 [CHF96/cong.-hour]	0.93	7.52	1.55
Fuel Costs 1998 [CHF98/cong.-hour]	0.98	8.02	1.63
Fuel costs 1996 [€ 98/cong.-hour]	**0.57**	**4.65**	**0.96**
Fuel costs 1998 [€ 98/cong.-hour]	**0.60**	**4.95**	**1.00**

Summary calculations: Following the ASTRA (1998) methodology, total congestion costs are calculated based on the most appropriate methodology:

– For congestion costs on motorways the model approach on the basis of fundamental traffic flow diagrams and traffic models seems to be the most appropriate, as it reflects the effects of increasing traffic on motorways, and results correspond to the rising number of reported traffic jams (see table 3-7).

– The results of congestion on motorways on weekends are derived from the in-depth analysis of traffic jam reports in 1995. The share of traffic jams on weekends compared to total traffic jams is assumed to be constant.
The analysis of traffic jam reports is also used to estimate congestion caused by accidents

mainly on motorways and inter-urban roads.

– For urban and suburban areas a mean-value of the overall estimation approach and the model approach is used to calculate the congestion costs.

Integration of approaches: The specific, disaggregated results are presented in the following tables (for total results refer to section 3.3). The results for the base year 1998 are as follows:

Table 3-13: Congestion costs 1998 road transport, in € million, 1998 prices

Cong. costs Road Prices 1998	**Mode**	**Vehicle-delay-hours** [mill.]	**Pass./ ship-ments per vehicle**	**Pass./ ship.-hours** [mill.]	**Total annual costs**				
					Time costs		**Fuel costs**		**Total**
Costs due to road congestion					€/h	Time costs [€ mill.]	€/v-hour	Fuel costs [€ mill.]	Total costs [€ mill.]
Motorways, inter-urban roads	Car weekdays	4.9	1.6	7.6	14.27	109.1	0.60	3.0	112.1
	Car weekends	1.5	2.0	2.9	7.88	23.1	0.60	0.9	23.9
	HGV weekdays	0.26	1	0.3	52.59	13.7	4.95	1.3	15.0
	LGV weekdays	0.23	1	0.2	48.92	11.3	1.00	0.2	11.5
Urban/sub-urban roads	Car weekdays heavy delays	8.7	1.4	12.0	13.78	164.9	0.60	5.2	170.1
	Car weekdays small delays	8.7	1.4	12.0	13.78	164.9	0.60	5.2	170.1
	Car weekends	1.2	2.0	2.3	7.88	18.2	0.60	0.7	18.9
Total due to road congestion		**25.3**		**37.3**		**505.2**		**16.5**	**521.7**
User costs due to accidents									
Motorways, inter-urban roads	Car weekdays	1.9	1.5	2.8	14.27	40.6	0.60	1.1	41.8
	Car weekends	0.9	1.7	1.6	7.88	12.7	0.60	0.6	13.3
	HGV weekdays	0.10	1	0.1	52.59	5.3	4.95	0.5	5.8
	LGV weekdays	0.09	1	0.1	48.92	4.4	1.00	0.1	4.4
Total delays due to accidents		3.0		4.7		63.0		2.3	65.3
Total		**28.4**		**41.9**		**568.2**		**18.8**	**587.0**

The following tables present congestion costs in road transport for the year 1996 and a forecast for 2005.

Table 3-14: Congestion costs 1996 road transport, in € million, 1998 prices

Cong. costs Road Prices 1998	**Mode**	**Vehicle-delay-hours** [mill.]	**Pass./ ship-ments per vehicle**	**Pass./ ship.-hours** [mill.]	**Total annual costs**				
					Time costs		**Fuel costs**		**Total**
Costs due to road conges-tion					€/h	Time costs [mill. €]	€/v-hour	Fuel costs [mill. €]	Total costs [mill. €]
Motorways, inter-urban roads	Car weekdays	4.3	1.6	6.7	14.04	93.6	0.57	2.5	96.0
	Car weekends	1.0	2.0	2.1	7.75	16.0	0.57	0.6	16.6
	HGV weekdays	0.18	1	0.2	48.13	8.7	4.65	0.8	9.6
	LGV weekdays	0.16	1	0.2	48.13	7.8	0.96	0.2	8.0
Urban / suburban roads	Car weekdays heavy delays	8.6	1.4	11.8	13.56	160.3	0.57	4.9	165.2
	Car weekdays small delays	8.6	1.4	11.8	13.56	160.3	0.57	4.9	165.2
	Car weekends	1.1	2.0	2.3	7.75	17.7	0.57	0.7	18.3
Total due to road congestion		**23.9**		**35.0**		**464.4**		**14.5**	**478.9**
User costs due to accidents									
Motorways, inter-urban roads	Car weekdays	1.5	1.5	2.2	14.04	31.6	0.57	0.9	32.4
	Car weekends	0.7	1.7	1.3	7.75	9.9	0.57	0.4	10.3
	HGV weekdays	0.08	1	0.1	48.13	3.8	4.65	0.4	4.2
	LGV weekdays	0.07	1	0.1	48.13	3.4	0.96	0.1	3.5
Total delays due to acci-dents		2.4		3.7		**48.7**		**1.7**	50.4
Total		**26.3**		**38.7**		**513.1**		**16.2**	**529.4**

Table 3-15: Congestion costs 2005 road transport, in € million, 1998 prices

Cong. costs Road Prices 1998	Mode	Vehicle-delay-hours [mill.]	Pass./ ship-ments per vehicle	Pass./ ship.-hours [mill.]	Total annual costs				
					Time costs		Fuel costs		Total
Costs due to road congestion					€/h	Time costs [mill. €]	€/v-hour	Fuel costs [mill. €]	Total costs [mill. €]
Motorways, inter-urban roads	Car weekdays	8.3	1.6	12.9	15.40	199.3	0.60	5.0	204.3
	Car weekends	2.5	2.0	5.0	8.50	42.1	0.60	1.5	43.6
	HGV weekdays	0.47	1	0.5	56.76	26.9	4.95	2.3	29.2
	LGV weekdays	0.52	1	0.5	52.80	27.5	1.00	0.5	28.0
Urban/sub-urban roads	Car weekdays heavy delays	8.9	1.4	12.2	14.88	182.0	0.60	5.3	187.3
	Car weekdays small delays	8.9	1.4	12.2	14.88	182.0	0.60	5.3	187.3
	Car weekends	1.2	2.0	2.4	8.50	20.1	0.60	0.7	20.8
Total due to road congestion		**30.7**		**45.7**		**679.7**		**20.7**	**700.5**
User costs due to accidents									
Motorways, inter-urban roads	Car weekdays	3.2	1.5	4.8	15.40	74.2	0.60	1.9	76.2
	Car weekends	1.6	1.7	2.7	8.50	23.2	0.60	1.0	24.2
	HGV weekdays	0.17	1	0.2	56.76	9.7	4.95	0.8	10.5
	LGV weekdays	0.15	1	0.2	52.80	8.0	1.00	0.2	8.1
Total delays due to accidents		5.1		7.9		115.1		3.9	119.0
Total		**35.8**		**53.6**		**794.8**		**24.6**	**819.4**

Sensitivity analysis: Sensitivity calculations have been carried out using national values of time. Values of time used in the official congestion cost study in Switzerland (ASTRA, 1998) are considerably higher than the in the UNITE project used overall values of time, especially for trips for business and commuting purposes, whereas the Swiss VOT for leisure trips are slightly lower than the overall UNITE values (see Table 3-16). The following table shows VOT for passenger transport used in the UNITE project and VOT used in the national congestion cost study (ASTRA, 1998).

Table 3-16: Values of time in € per hour, 1998 prices (Nellthorp et al. 2001; ASTRA 1998). Values of time of the national congestion cost study have been adjusted to the respective years

	VOT UNITE			VOT CH (ASTRA, 1998)			Variation		
	Business	Commuting	Leisure	Business	Commuting	Leisure	Business	Commuting	Leisure
1996	37.9	10.1	6.7	62.5	15.6	6.3	+65%	+55%	-7%
1998	38.5	10.2	6.8	64.1	16.0	6.4	+66%	+57%	-6%
2005	41.6	11.0	7.4	69.2	17.3	6.9	+66%	+57%	-6%

The following table shows the results of the sensitivity analysis:

Table 3-17: Results of the sensitivity analysis, congestion costs in € million, 1998 prices

	1996	1998	2005
Congestion costs road: VOT UNITE	529.4	587	819.4
Congestion costs road VOT CH	769.2	852.6	1 175.7
Variation	+45.3%	+45.2%	+43.5%

If congestion costs in road transport were calculated using national values of time, the resulting congestion costs would be approx. 45% higher. However, the ASTRA (1998) applied national values of time are not based on a national study but on several recent studies on time costs in road transport (for details see ASTRA (1998)).

The second step of sensitivity considerations in congestion costs road is the comparison with recent studies on congestion costs in Europe and Switzerland in particular. In INFRAS/IWW (2000), congestion costs in road transport have been calculated with a dead-weight loss approach and congestion data of a traffic model. Apart from the above-mentioned national congestion cost study (ASTRA, 1998), a recent study on congestion costs in the Swiss Canton of Zug has been carried out (INFRAS, 2001). That study compared peak and off-peak travel times within an empirical estimate. It also includes a rough extrapolation of congestion costs of the Canton of Zug to overall Swiss values based on vehicle-km. The following table shows the results of the two mentioned studies. The respective values have been adjusted to € and 1998 prices.

Table 3-18: Results of different studies on congestion costs in Switzerland in € million, 1998 prices

	UNITE (Base year 1998)	UNITE CH-VOT (Base year 1998)	ASTRA 1998 (Base year 1995)	INFRAS/IWW 2000 (Base year 1995)	INFRAS 2001 (Zug) (Base year 2000)
Congestion costs	587.0	852.6	809.2	874.3	2 248.6

Since lower values of time have been applied in the UIC-study (INFRAS/IWW, 2000), the difference to the results of UNITE is based on a higher share of congested traffic.[20] The results of an extrapolation of the regional congestion study in the Canton of Zug shows much higher congestion costs for Switzerland. The main difference to the UNITE pilot account calculations is the fact that in Zug even very small delays (peak-off-peak differences) have been taken into account which were not considered as congestion in the ASTRA Study, the basis for the pilot account methodology.

Altogether it can be stated that the obtained results of the pilot accounts is based on the lower bound of congestion cost calculations in Switzerland (with the exception of the regional study of the Canton of Zug). The difference to the national study (ASTRA, 1998), which is broadly accepted, is only based on different values of time used within UNITE to guarantee comparability. The quantity structure regarding the share of congested traffic in Switzerland shows a plausible development and goes in line with the results of the national study.

20 Within the UIC-study, the IWW- VACLAV model was used to model congestion.

3.3.2 Rail

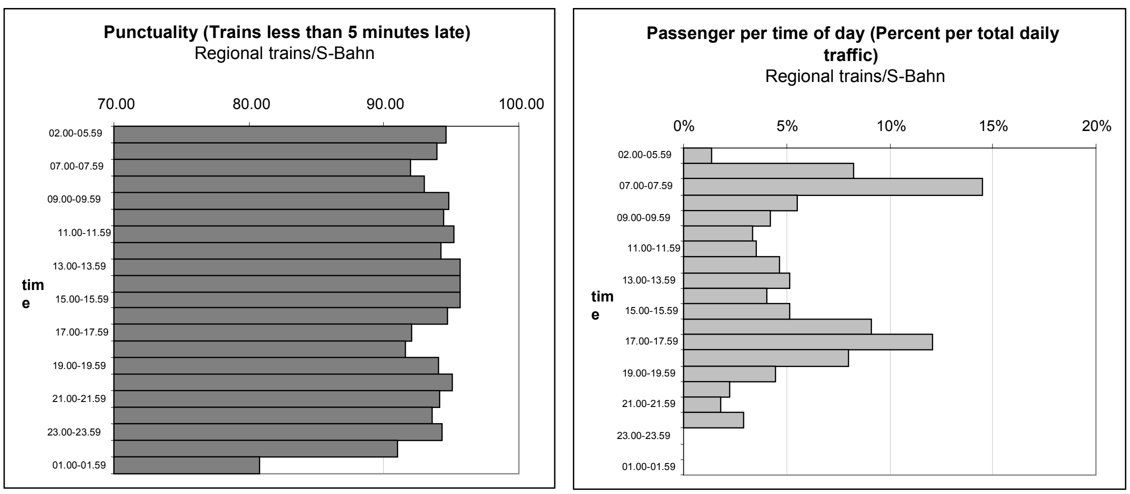
Methodology congestion costs rail passenger

The aim is to estimate the number of passengers affected by the delays in order to calculate the value of the time lost due to delayed trains. The following facts must be taken into account:

1. Computations are based on arrival delays,
2. The punctuality index (percentage of trains arriving less than 5 minutes late) is lower in peak hours (6.00-8.00 a.m. and 4.00-8.00 p.m.), this applies for all train types,
3. At the same time these are the hours of day when trains will be well occupied and therefore delayed peak-hour trains have to be weighted more than the rest,
4. Each train category has its own delay structure. Separate estimations must be made for each train category.

The following figure illustrates an example for the two key distributions used for the estimation of the number of delayed passengers:

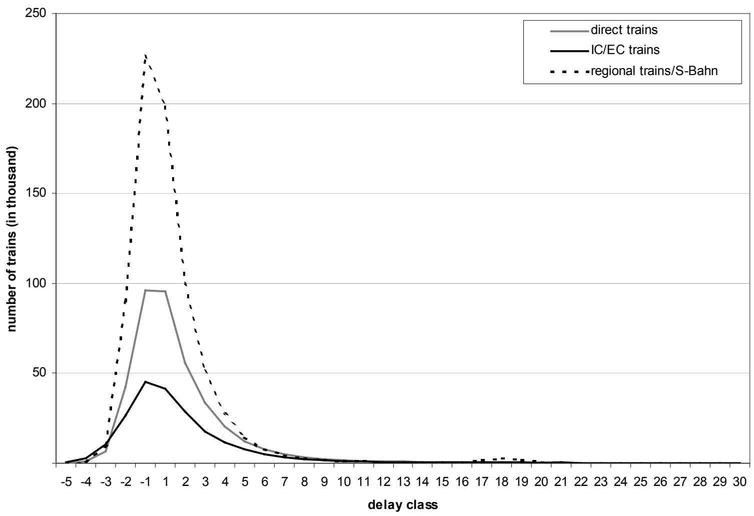
Table 3-19: Punctuality and passengers per time of day



Firstly, using the distribution of train passengers (right side of the figure above) and the total number of passengers travelling on IC/EC-trains, the number of passengers per time slot (2:00 - 5:59 a.m., 6:00-6:59 a.m., etc.) was calculated. For each time slot, the punctuality distribution (left side of figure above) supplies information on how many of the travelling passengers were arriving late/on time.

Using the distribution of delayed trains per delay category (see Figure 3-20 below) an average delay for trains with delays of more than 5 minutes can be calculated. The number of affected passengers is then multiplied by the average delay and added for all hours of day. The result is the total delayed passenger hours for each train category. After splitting the passenger-delay-hours into business, leisure and commuting the congestion cost for “Rail passenger” is calculated. The value of time for “inter urban rail - in vehicle waiting time – congested/delayed” was used. Distributions and transport performances were based on SBB data. A projection for all Swiss railways on the basis of transport performance data (passenger-km) was made.

Table 3-20: Distribution of delays for regional, direct and IC/EC-trains



Backcast methodology rail passenger: From the two key distributions (punctuality, passengers per time of day) only the latter was adjusted in order to backcast from 1998 to 1996. Statistics on punctuality of the SBB show that there is only very little fluctuation. Therefore the 2001 punctuality-distribution was used for 1996 as well. The passenger per time of day-distribution is available for all years between 1996 and 1999. The appropriate one was used for 1996. Performance data (passenger-km) for each train category is available from 1995 up until 2000 and the appropriate data was used for 1996.

Forecast methodology rail passenger: For the 2005 forecast the 1998 distributions were used. The performance data was projected continuing linear trends from 1995 through to 2000. The projection factor Federal Railways to all Swiss Railways proved to remain unchanged from 1995 to 1997 (88:12) and was therefore also adapted for 2005.

Methodology time costs Rail Freight: The information on the punctuality of freight trains was slightly less detailed than for passenger trains. Again the aim was to estimate the amount of goods (in tonnes) affected by delays. The following approach was used:

Using the standardised (all trains = 100%) distribution of delayed trains per delay class and the total number of tonnes per class was computed. For each class the number of tonnes is multiplied with the class centre and added up, giving the total delayed tonne-hours. This figure can then be multiplied with the appropriate value of time.

Backcast methodology rail freight: The SBB annual reports provide information on performance and volume for transit and inland-/import-export-goods trains for 1996. This data was combined with the 2000 delay distribution (number of trains per delay class) assuming that there were only minor changes.

Forecast methodology rail freight: As for backcasting the 2000 delay distribution (number of trains per delay class) was also used for forecasting 2005. The performance data was extrapolated using linear trends on the time series 1995-1999.

3.3.3 Road Based Public Transport

For Switzerland no study on congestion or delay costs in public transport exists so far. A survey among important urban and regional public transport companies revealed, that the majority of companies don't collect and analyse delay or congestion related data systematically. It was also stated, that delays are primarily a problem for urban public transport companies. Regional public transport services are mainly operated as feeder lines to regional train station in smaller cities and towns as well as in mountainous regions and therefore seldom subject to substantial delays. The largest operator for regional public transport services 'Postbus' (a former branch of the Federal Swiss Post and Telecommunication Company PTT) expressed, that only a very small number of services – mostly operating in urban and suburban areas – suffer from delays due to interference mainly with individual road transport during peak hours. However, no data on the extend of those delays was available. As a consequence, the focus will be set on delays of urban public transport services.

In ASTRA (1998) first calculations have been made concerning small delays in peak-hours (travel time differences of tramways, trolley- and diesel-buses in peak hours versus off-peak traffic conditions). Unlike in rail transport, public transport services circulate during peak-hours on an adjusted timetable which considers delays caused due to higher numbers of passengers and therefore longer stops at stations, interference with individual road traffic and mutual interference with other public transport services (due to infrastructure scarcity). Especially public transport modes which share infrastructure with individual road traffic (such as trolley buses) suffer particularly under these conditions and show a significant increase in driving time during peak hours. However, public transport companies consider these framework parameters within the timetable layout and publish correspondingly adjusted timetables.[21] As a consequence, operators have to introduce additional vehicles during peak-hours to keep to the scheduled frequencies. The additional driving time in urban public transport services during peak hours corresponds to small delays in individual road transport due to disturbed traffic conditions.

In a second step, the observed delays to the respective timetable of scheduled public transport services has to be considered. The survey among urban public transport companies showed that very few companies collect systematically data on extraordinary delays (delays to the scheduled arrival time). Only those companies, which have an electronic traffic control and management system possess a comprehensive data set on extraordinary delays. Most companies still have a communication system, in which the driver of a vehicle calls the operation control centre when he's delayed and measures by the operation centre have to be taken (exchange of courses, use of additional vehicles etc). Because it's the drivers liability to call the operation centre in case of extraordinary delays, most data set are incomplete (drivers only call the operation centre, when the delay couldn't be recovered at the terminus station).

To estimate congestion costs in public transport, total congestion costs have to be extrapolated from companies, which collect delay data systematically. The urban public transport provider in Zurich (VBZ) has an electronic traffic control system, which collects comprehensively extraordinary delays as well as travel time differences during peak hours versus off-peak hours. VBZ is by far the largest urban public transport company in Switzerland (approx. 32% of all urban public transport passengers are covered within) and therefore a starting point for extrapolations.

21 On most public transport timetables in Switzerland, the time of departure and average travel times are published. During peak-hours, departure times normally could be met, while the actual travel time is slightly longer than the published one.

Methodology 1996 and 1998: In order to calculate congestion costs in urban public transport a two-step approach was used. First of all, small delays have been estimated on the basis of measured travel time differences between terminus stations during peak hours. Second, user costs due to extraordinary delays (normally defined in urban public transport as delays of more than 3 minutes) have been calculated.

The calculation steps for **small delays** are as follows:

1. Compilation of travel time differences in peak hours versus off peak hours in Zurich (all tramway, trolley bus and bus services):
   Morning peak: 6-8.30 a.m.
   Evening peak: 4-6.30 p.m.
2. Estimation of affected passengers based on time-differentiated passenger statistics (Passengers during morning and evening peaks for all tramway, trolley bus and bus services)
3. Calculation of passenger delay-hours for 1996, 1998 and 2000.

Mode	Total delay-hours			Average delay per passenger
	1996	1998	2000	2000 [seconds per passenger]
Tramway	825 630	794 096	806 357	39
Trolley	506 716	487 363	494 887	94
Bus	128 086	123 194	125 096	36
Minibus	2 595	2 496	2 535	10
Delay-hours total	**1 463 027**	**1 407 148**	**1 428 875**	**48**

4. The following assumptions on the purpose of a trip during peak-hours have been made: Business 5%, Commuting 75%, Leisure 20% (based on BFS, 1996)

Delay hours per trip purpose	1996	1998	2000
Tramway			
Business	41 282	39 705	40 318
Commuting	619 223	595 572	604 768
Leisure	165 126	158 819	161 271
Total	**825 630**	**794 096**	**806 357**
Trolley bus			
Business	25 336	24 368	24 744
Commuting	380 037	365 522	371 166
Leisure	101 343	97 473	98 977
Total	**506 716**	**487 363**	**494 887**
Bus (Bus+Minibus)			
Business	6 534	6 284	6 382
Commuting	98 011	94 267	95 723
Leisure	26 136	25 138	25 526
Total	**130 681**	**125 690**	**127 630**

5. Extrapolation from Zurich delay data to Switzerland based on passenger numbers. The following factors have been used to extrapolate from Zurich results to overall Swiss results (extrapolation based on passenger per mode):

Extrapolation factors	1996	1998	2005
Tramway	2.04	2.04	2.04
Trolley bus	6.27	5.63	5.16
Bus	4.96	5.04	4.47
Total	3.14	3.13	2.96

6. Calculation of congestion costs with UNITE Values-of-time for Switzerland (Nellthorp et al. 2001, VOT PPP-adjusted, in €, 1998 prices)

	1996	1998	2005
Tramway	17 703 824	17 292 810	19 599 396
Trolley bus	33 365 655	29 317 300	30 338 809
Bus	6 811 491	6 772 486	6 787 093
Total	**57 880 970**	**53 382 597**	**56 725 298**

The congestion costs of **delays to scheduled arrival time** are estimated as follows:

1. Total delay figures for Zurich are collected in an aggregated way (yearly statistic on the number of delays per delay class, e.g. tramway: 3 000 delays 4-6 minutes, 900 delays 6-10 minutes and so on, total approx. 40 000 registered delays of more than 3 minutes in 2000). This statistic doesn't contain any information on time of the day, when the delay happened. This information however would be essential to estimate the number of affected passengers. Therefore we analysed a random sample of daily delay-reports, which contain data on the transport mode, time and magnitude of the delay. Result was a distribution of delays over the different transport modes and time periods (peak, off-peak).

	Mo-Fr		Sa-So		Total
	No. of delays	Average delay [min.]	No. of delays	Average delay [min.]	
Tramway	41.7%	5.4	48.1%	5.5	44%
Urban bus (Trolley + Diesel)	43.8%	6.4	27.8%	5.4	39%
Suburban bus	14.5%	5.9	24.1%	5.9	17%
Total	**100.0%**	**5.6**	**100.0%**	**5.6**	**100.0%**

2. The analysis of the allocation of the number of delays to the period of the day shows the following result:

Time	5-6.30	6.30-8.15	8.15-13.30	13.30-16.00	16.00-18.00	18.00-19.30	19.30-24.00
Weekdays							
Tramway	0.3%	17.1%	23.4%	13.0%	29.1%	11.1%	6.0%
Urban bus	0.6%	23.6%	8.1%	6.3%	46.0%	13.8%	1.5%
Suburb. bus	0.0%	32.7%	11.8%	6.4%	36.4%	10.9%	1.8%
Weekends							
Tramway	3.8%	4.6%	27.7%	24.6%	17.7%	5.4%	16.2%
Urban bus	4.0%	2.7%	21.3%	30.7%	20.0%	13.3%	8.0%
Suburb. bus	0.0%	0.0%	23.1%	26.2%	16.9%	20.0%	13.8%

3. Based on the detailed analysis of extraordinary delays, the following average delay per mode and period of day could be derived:

Delay [Minutes]	5-6.30	6.30-8.15	8.15-13.30	13.30-16.00	16.00-18.00	18.00-19.30	19.30-24.00
Weekdays							
Tramway	5.0	5.4	5.4	5.2	5.5	5.3	5.0
Urban bus	5.0	6.8	5.4	5.1	6.8	5.8	5.0
Suburb. bus	0.0	6.7	6.5	5.4	6.3	6.4	5.0
Weekends							
Tramway	6.2	5.0	5.3	5.9	5.8	5.0	5.4
Urban bus	5.0	5.0	5.0	5.9	5.2	5.3	5.0
Suburb. bus	0.0	0.0	6.4	6.2	5.5	5.0	6.3

4. The number of affected passengers was estimated based on average load factors of tramways and buses:

Load factors	5-6.30	6.30-8.15	8.15-13.30	13.30-16.00	16.00-18.00	18.00-19.30	19.30-24.00
Weekdays							
Tramway	33	100	50	83	100	83	33
Urban bus	22	66	33	55	66	55	22
Suburb. bus	15	46	23	38	46	38	15
Weekends							
Tramway	17	33	80	102	78	75	33
Urban bus	11	22	49	66	49	49	22
Suburb. bus	8	15	35	46	35	35	15

5. The following assumptions on the respective purpose of a trip have been used:

	5-6.30	6.30-8.15	8.15-13.30	13.30-16.00	16.00-18.00	18.00-19.30	19.30-24.00
Tramway/buses Weekdays							
Commuter	85.0%	85.0%	30.0%	15.0%	65.0%	50.0%	10.0%
Business	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%
Leisure	10.0%	10.0%	65.0%	80.0%	30.0%	45.0%	85.0%
Tramway/buses Weekends							
Commuter	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
Business	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Leisure	97.5%	97.5%	97.5%	97.5%	97.5%	97.5%	97.5%

6. Results for 1996, 1998 and 2005 (total delay-hours per purpose of a trip):

Delay hours	1996	1998	2005
Commuter	200 387	193 497	210 733
Business	16 629	16 057	17 487
Leisure	136 063	131 384	143 088
Total	**353 078**	**340 938**	**371 308**

7. Finally the results from Zurich have been extrapolated based on total passenger numbers. The following table shows the results for congestion costs due to extraordinary delays in Switzerland in €, 1998 prices

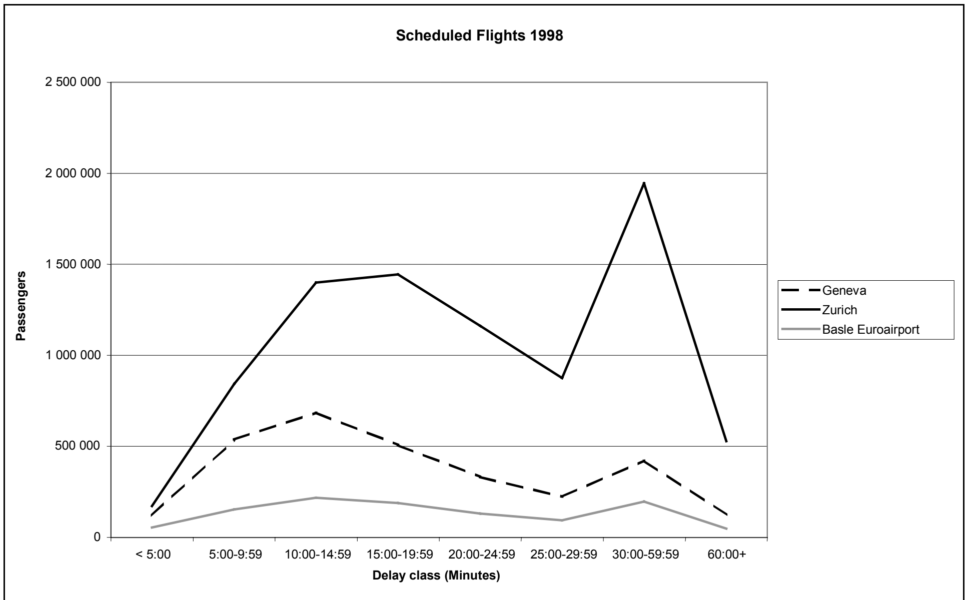
	1996	1998	2005
Costs in €, 1998 prices	10 602 125	10 372 250	11 533 438

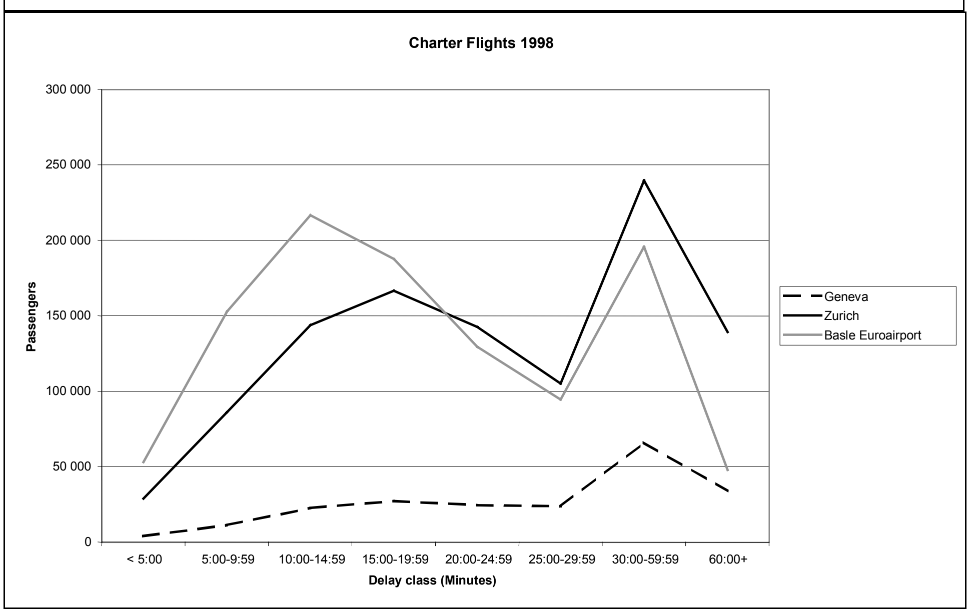
Forecast methodology 2005: It was assumed, that the structure of delays remains constant within the next years (at least for Zurich this assumption seems to be justified, since total delay numbers remain within the last few years on a constant level of around 40 000 a year). Traffic numbers are taken from the 'supplier operating cost'-chapter, where a forecast for 2005 mileage and passengers have been made.

3.3.4 Aviation

Methodology delay costs: Compared to the congestion costs in "Rail" the estimation of congestion costs for aviation was somewhat less complex since the Federal Office for Civil Aviation (BAZL) was able to supply detailed data on delayed passengers for all three Swiss international airports (Zurich, Geneva and Basle).

Table 3-21: Distribution of delays on Swiss airports, scheduled and charter flights for 1998 (departure delays)





The number of delayed passengers for each delay class (e.g. 15-20 minutes) is multiplied with the class centre and then added up, giving the delayed passenger-hours. For the computation of delay costs in aviation only delays greater than 15 minutes are considered. The distributions above show a peak at around 10 to 20 minutes and a second one between 30 and 60 minutes.

A travel-purpose split model is applied in order to compute the congestion costs for "air". Due to the lack of a sound empirical background for travel purpose assumptions, two different scenarios were chosen: Scenario A (leisure/business) = 85/15, Scenario B = 75/25. The value of time for "air- in vehicle waiting time – congested/delayed" was used. The following table shows the aggregated input data from all three Swiss airports for scheduled and charter flights. While the delays on charter flights only rise moderately from 1997 to 2005 (30 %

more delayed passengers), the situation for scheduled flights is more drastic (77% more delayed passengers in 2005 than in 1997).

The resulting costs will be discussed later in this report.

Table 3-22: Delayed flights, passengers and resulting time costs for Swiss airports

	1997			1998			2005 forecast		
	Sched.	Charter	Total	Sched.	Charter	Total	Sched.	Charter	Total
Delayed Flights	180 804	17 997	198 801	198 538	17 523	216 061	n.a.	n.a.	n.a.
Delayed Pass (mill.)	11.3	2.8	14.1	12.4	2.5	15.0	20.1	3.7	23.8
UC Air Scen A (€ mill.)	93.2	17.7	110.9	112.9	19.0	131.8	223.7	56.3	280.0
UC Air Scen B (€ mill.)	107.9	20.6	128.4	130.1	22.0	152.6	273.5	66.7	340.3

Backcast methodology: The Federal Office for Civil Aviation (BAZL) provides delay statistics also for 1997. The same computation procedure as for 1998 was used for 1997 and used as "best guess" figure for 1996.

Forecast methodology: The standardised delay distribution (number of delayed passengers per delay class) is used in combination with ITA forecasts on transport volumes for 2005. These figures are available for all three Swiss international airports. This approach implies that there will be no significant change in the delay structure.

Additional Airline costs: In addition to the time costs Swissair was able to supply a rough estimate on additional costs inflicted on the airline due to the delays. These include:

- additional costs for the change of aircraft,
- additional flight operation related costs (e.g. fuel costs, extra personnel costs),
- costs for vouchers (food/beverage/phonecards) issued for delayed passengers,
- lost income from passengers booked on another companies connection flight,
- replacement transport: hired aircraft/buses/taxi,
- costs for hotels,
- denied boarding compensation,
- additional catering costs, etc.

Swissair supplied data for 1999 and 2000 together with their own delay statistics. An indicator (additional costs per delay-passenger hour) was used to project the figures on all delayed movements and the other reference years (1996 and 2005). However, the results are only provisional and include mainly costs which lead to additional expenditures.

3.4 Accident Costs

Beside the back- and forecast methodology, two issues concerning the calculation of the accident costs deserve some further methodological discussion in this section:

- the consequences of the victim perspective of UNITE with regard to cost allocation,
- the distinction between system-internal and -external costs.

In section 2.5.1, it is mentioned that UNITE follows in the case of accident costs the "victims perspective" (monitoring perspective). This perspective results in the case of road transport in **allocation problems**:

- The administrative costs of the police and legal system are assessed as total costs for all road accidents. Only if the causer or the perpetrator perspective is taken, it is possible to allocate these costs as part of the total accident costs to the “correct” vehicle category, namely the category that causes the accident. In the case of the monitoring perspective an arbitrary distribution (e.g. 50:50) has to be chosen.
- A similar problem arises with the allocation of payments of the auto liability insurances. The data of the insurance companies are differentiated according to the different vehicle categories. Thus, these payments can be considered as vehicle category specific contribution to the internalisation of accident costs. In the case of the monitoring perspective, this direct allocation is not possible. This perspective shows the number of victims in the different vehicle categories but this number is irrelevant for the liability insurance payments that should be attributed to this specific vehicle category as contribution to internalisation.

The conclusion is that with the monitoring perspective it is actually not possible to assess vehicle category specific internal and external accident costs unless arbitrary cost allocation is accepted. This cost allocation problem does not occur if the causer perspective is taken instead. Against this background and because studies on accident costs in Switzerland normally take the causer perspective we present the results for both perspectives in section 4.4.

Another important methodological aspect is the distinction between **internal and external costs with regard to the risk value**, i.e. the willingness-to-pay (WTP) for avoiding death casualties or injuries caused by traffic accidents. Looking at the order of magnitude of this "cost block", this distinction crucially influences the total level of the external accident costs. In the theoretical part of UNITE (see Doll et al., 2000) it is mentioned that this distinction depends on the risk awareness of the individuals participating in transport. In our view, it is rather the perspective that is decisive for where to draw the line:

- **Perspective of the transport system**: Under this perspective the risk value (WTP-value) is an internal cost block because it refers to actors of the transport system. Only the grief and suffer of the relatives would be transport system external. However, in Doll et al. (2000) it is made clear that due to data and information problems it is not possible within UNITE to separate this part of the WTP-value from the part referring to the victim of the traffic accident itself. We do not recommend to use the notion "the risk value is internalised" because we understand internalisation as cost allocation according to the "polluter-pays-principle" which isn't the case here. The external cost part is limited to those transfer payments from the social security to persons involved in accidents that are not covered by payments of the auto liability insurances (i.e. transport system internal insurances) to the social security. With regard to the objective of the accounts, namely to prepare information about total costs and revenues of the transport system, this perspective - or rather the very similar perspective per transport mode road, rail etc. - is the relevant one.

– **Perspective of the individual transport user**: If not cost and revenue accounting but pricing is in the centre of interest, the perspective of the individual transport user or actor becomes relevant. Here, we don't see good reasons why the risk value should be considered as internal. The problem here is that the victims perspective of UNITE is not very helpful for discussing this point. Relevant is the "producer perspective", i.e. the causer or perspective. The question is not whether the victims are aware of the risk but rather whether the causer of an accident has to bear the consequences of his misconduct. This perspective is also taken by the insurance system: The fact that auto insurance companies effect direct payments to accident victims that go beyond the compensation of the social security for its payments to accident victims can only be interpreted as direct compensation of a part of the damages to the victims. Thus, the insurance system considers these damages as external, otherwise there would be no need to effect such payments.
  We therefore conclude that the risk value of the non-causer of accident should be considered as external. To get the total external costs of the "cost block" risk value, it must be increased by the payments of the social security that are not covered by compensations of the auto liability insurances in favour of the social security and reduced by the direct payments of the auto liability insurances to the victims.

With the methodological discussion above we would like to emphasise that the choice of the victims perspective in UNITE has advantages with regard to data collection (the information about the causer of accidents is in many countries not immediately available) but it has considerable disadvantages when it comes to cost allocation and the distinction between internal and external cost parts that is very relevant for pricing. The latter, however, is not the main goal of the figures collected in transport accounts.

For the derivation of the accident costs of the years 1996 and 2005 the procedure described below is chosen.

Backcast methodology: The total number of reported accidents is available for the year 1996 for **road and rail transport**. The relation between reported and non-reported accidents is assumed to remain unchanged between 1998 and 1996. The same applies for the distribution of the accidents to the different vehicle categories and according to the severity of the accidents. To summarise, we start from the total number of reported accidents and assume that the "structure" of traffic accidents didn't change between 1996 and 1998. For **aviation**, the number of accidents didn’t change because the 1998 figure is an average of the years 1988 - 1999.

For the valuation of the accidents, the following changes in the valuation bases have been taken into account:

– lower GDP/capita in 1996 (see table 2.1) to adjust first of all the risk value for fatalities and injuries, i.e. the VOSL and fractions therefrom,
– development of average salaries in Switzerland to value production losses,
– development of costs in the health sector to value the medical costs,
– development of price index (see table 2.1) to show the results in 1998 prices.

Forecast methodology: For the assessment of the accident costs for the year 2005, forecasts concerning the changes in the accident rates are needed. The approach chosen for **road transport** is a mix of trend extrapolation (basis: development of accident rates between 1970 and 1999) and qualitative assessment of the Schweizerische Beratungsstelle für Unfallverhütung

verhütung BfU ("Swiss Advice Centre for Accident Prevention").[22] The calculations of the 2005 accident costs start from the changes of the accident rates between 1998 and 2005 given in the table below. The rates given in the table and the forecast of the vehicle kilometres for the year 2005 (see table 2.2) were used to calculate the total number of accidents, fatalities and injuries.

Table 3-23: Assumed development of road accident rates, 1998-2005

Accident rate	Change / a	Total change
Number of accidents / vkm	- 1.1%	-7.5%
Number of fatalities / vkm	- 3.0%	-19.2%
Number of injuries / vkm	- 1.5%	-10.0%

The rates used within UNITE lie between available forecasts in the literature:

– In ECMT (1998) it is assumed that the accident rate will further decrease in the next years. It is estimated that the decline achieved in the last years will continue in the next fifteen years and will bring down the accident rate to less than half of the level in the mid-nineties.
– In INFRAS/IWW (2000) an accident forecast 2010 is made. The change of accident rates - measured in casualities per vehicle kilometre - is assessed according to the development in the last decade (1985-1995). Within the frame of regression analysis, equations were estimated for four country groups in Europe. The future accident rates were calculated by extrapolation. For Switzerland with its comparatively low accident rate a decrease of 5% is predicted until 2010.

The assumptions regarding the development of the accident rates in **rail transport** are summarised in table 3-24 below. As in the case of road transport, the figures are derived from a trend extrapolation (years 1975-1997). The comparatively high decreases per year can also be found if only the recent years are considered.

Table 3-24: Assumed development of rail accident rates, 1998-2005

Accident rate	Change / a	Total change
Number of accidents / train-km	- 3.2%	- 20.4%
Number of fatalities / train-km	- 4.2%	- 25.9%
Number of injuries / train-km	- 5.3%	- 31.7%

As in the case of the backcast, no adjustment was made for **aviation** because the 1998 accident rates represent an eleven-year-average.

The valuation follows the same approach as used for the backcast. Available forecasts about the development of the GDP, salary level etc. were used to adjust the cost figures.

22 An expert interview has been carried out with Mr. J. Thoma of the BfU (leader of the BfU project "Development of traffic safety in Switzerland") to verify the figures resulting from the trend extrapolation.

3.5 Environmental Costs

3.5.1 Air Pollution

The calculations carried out with the ExternE model followed the method as described in Link et al. (2000) and especially in the annex to this report.

Backcast methodology: For all three relevant transport modes 1996 figures for the emissions of the different air pollutants and - in the case of rail - the energy consumption and electricity production mix are available. These changes and the changes in the number of population (see table 2.1) serve as base for the adjustment of the 1998 results. The following tables summarise the emissions data for the three modes road, rail and air transport.

In the case of **road transport**, the total emissions measured in tonnes / year (t/a) of most air pollutants decreased in Switzerland though there was quite a substantial increase in traffic volume between 1996 and 1998 (see table 2.2): The higher share of "cleaner cars" overcompensated the growth of traffic volume. This does not apply to fuel consumption and CO_2 emissions respectively: Here, the emissions in the UNITE base year 1998 are about 3% higher than two years before in 1996.

Table 3-25: Emission of air pollutants of road transport, in t/a, 1996[23]

Vehicle categories	CO2	NMVOC	NOx	SO2	PM10 Total	Particles
Motorcycles, bikes	142 291	3 450	330	18	34	
Cars	9 755 281	41 390	38 804	1 340	2 440	316
Coaches	89 428	141	1 105	28	129	55
Buses	196 303	313	2 871	62	284	152
Light goods vehicles	868 746	2 689	4 060	165	430	254
Heavy goods vehicles	1 820 100	2 665	21 259	578	2 850	1 318
Total emissions	12 872 149	50 648	68 429	2 191	6 167	2 095

Both, energy consumption of **rail and of electrified urban public transport** increased between 1996 and 1998. Obviously, the limited increase in traffic performance (see table 2-3) is not compensated by a higher energy efficiency. With regard to the emissions of air pollutants during the electricity production, there is significantly higher share of nuclear compared to 1998 and the still very limited share of "others" (incl. oil-thermic). Against this background, the emissions of air pollutants of rail and electrified urban public transport is - as in the year 1998 - very limited.

23 Source: BUWAL (2000).

Table 3-26: Energy consumption and electricity production mix for rail transport and urban public transport, 1996[24]

Transport mode	Energy cons. in 1'000 kWh	Electricity production mix, share in %		
		Hydro	Nuclear	Others
Rail transport	**2 099 719**	73.3%	26.1%	0.6%
Freight	861 401			
Passenger	1 238 318			
Urban public transport	**211 423**	53.9%	43.0%	3.1%
Tramway	124 107			
Trolley bus	87 316			

Looking at the high annual growth rates in the **aviation** sector (see table 2.5) the lower figures for the emissions of air transport in the year 1996 compared to the UNITE base year 1998 (see table 2-18) could be expected.

Table 3-27: Emissions from aviation in Switzerland, in t/a, 1996[25]

Emission category	Fuel	CO	VOC	NOx	SO2	Pb
National airports	137 913.6	2 338.8	299.7	1 658.3	137.5	0.3
Regional airports	3 831.0	766.9	22.1	26.5	3.1	0.5
Airfields	2 078.7	1 012.2	25.7	8.7	1.1	0.8
Transit large airplanes	283 866.2	468.7	45.1	4 502.1	283.9	0.0
Transit small airplanes	7 679.0	1 493.4	10.2	68.0	4.7	2.7
Transit Helicopter	6 033.4	6.9	1.5	23.5	6.0	0.0
Emissions during fuelling	0.0	0.0	123.2	0.0	0.0	0.0
Fuel dumping	0.0	0.0	101.8	0.0	0.0	0.0
Total	441 402.1	6 086.8	629.2	6 287.1	436.3	4.3

Forecast methodology: For the derivation of the 2005 emission data, we could rely on official estimates in the case of road transport. For aviation, the emissions were calculated by using comprehensive traffic volume forecasts and expert interview based assumptions concerning the improvement in the emission abatement technology of aircrafts and the higher share of cleaner aircrafts respectively. The figures for rail and urban public transport base on trend extrapolation and expert opinions.

The trend in **road transport** between 1996 and 1998 continues in the period 1998 to 2005: Still, the "technology effect" over compensates the traffic volume effects. For all air pollutants - with the exemption of CO_2 - partly substantial reductions in emission volumes in tonnes / year (t/a) are expected though traffic volume will further grow.

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24 Sources: BFS (2000) and BFS (1997).

25 Source: BAZL (1999) and ITA (1999).

Table 3-28: Emission of air pollutants of road transport, in t/a, 2005[26]

Vehicle categories	CO2	NMVOC	NOx	SO2	PM10 Total	Particles
Motorcycles, bikes	155 789	2 627	391	4	37	
Cars	10 030 714	9 027	14 601	293	2 574	227
Coaches	113 654	112	929	3	127	30
Buses	200 491	198	1 935	5	205	67
Light goods vehicles	1 118 625	785	2 426	31	346	113
Heavy goods vehicles	2 196 908	1 723	14 778	56	2 222	507
Total emissions	13 816 181	14 472	35 060	392	5 510	944

For **rail and electrified urban public transport** a further increase of energy consumption is predicted. It can be assumed that in the case of rail transport this increase can't fully be covered electricity produced in hydroelectric power stations leading to an increase of the share of nuclear energy in the production mix.

Table 3-29: Energy consumption and electricity production mix for rail transport and urban public transport, 2005[27]

Transport mode	Energy cons. in 1'000 kWh	Electricity production mix, share in %		
		Hydro	Nuclear	Others
Rail transport	**2 351 227**	85.5%	14.3%	0.2%
Freight	1 004 590			
Passenger	1 346 637			
Urban public transport	**236 388**	60.9%	35.3%	3.8%
Tramway	145 951			
Trolley bus	90 437			

The further strong growth of **aviation** results in improvements in the emission abatement technology. A somewhat lower but still significant increase of air pollutants exhausted on the Swiss airports and during flights passing Switzerland is observed. The fuel consumption, for example is expected to increase by more than 30% between 1998 and 2005.

The values used for the valuation of the damages in the ExternE model have been adjusted according to changes in the Swiss GDP / capita (see table 2.1). The functions (e.g. exposure-response functions, transmission functions) within the model haven't been adjusted.

26 Source: BUWAL (2000).

27 Sources: Information from the SBB, trend extrapolation for UPT (base period 1990-1997).

Table 3-30: Emissions from aviation in Switzerland, in t/a, 2005[28]

Emission category	Fuel	CO	VOC	NOx	SO2	Pb
National airports	183 521.4	3 104.9	396.8	2 205.6	182.9	0.4
Regional airports	5 145.8	1 030.1	29.8	35.6	4.2	0.7
Airfields	2 792.1	1 359.6	34.5	11.7	1.4	1.0
Transit large airplanes	412 374.5	680.8	65.5	6 540.2	412.4	0.0
Transit small airplanes	11 155.4	2 169.4	14.8	98.7	6.8	3.9
Transit Helicopter	8 104.0	9.3	2.0	31.5	8.1	0.0
Emissions during fuelling	0.0	0.0	177.8	0.0	0.0	0.0
Fuel dumping	0.0	0.0	146.9	0.0	0.0	0.0
Total	623 093.2	8 354.2	868.1	8 923.5	615.9	6.1

3.5.2 Global Warming

The method of calculating costs of CO_2 emissions basically consists of multiplying the amount of CO_2 emitted by a cost factor. Due to the global scale of the damage caused, there is no difference how and where the emissions take place.

The main methodological issue debated within the UNITE team is the question whether damage cost or avoidance cost figures per tonne of CO_2 should be used. As mentioned in section 2.6.2, the calculations base on avoidance costs estimated for Europe and a sensitivity cost figure for Switzerland.

Backcast / forecast methodology: The figures for the CO_2 emissions for the years 1996 and 2005 are given in the tables above in section 3.5.1.

3.5.3 Noise

As mentioned in section 2.6.3, the methodology for quantifying noise costs was extended to the calculation of physical impacts. Costs for the following endpoints are quantified:

- Myocardial infarction (fatal, non-fatal),
- Angina pectoris,
- Hypertension ,
- Subjective sleep quality.

These health impacts are added to the results following the Hedonic Pricing approach. It is assumed that the results from the Hedonic Pricing approach only contain the annoyance caused by noise but not the adverse impacts of noise on health.

28 Source: BUWAL (2000).

The derivation of the noise costs for the years 1996 and 2005 proves to be extremely difficult because it is almost impossible to make useful general assumptions. Because noise is a local effect, local information should be collected and aggregated. Such a procedure is far beyond of the scope of UNITE.

Backcast methodology: For the derivation of the 1996 figures a further difficulty arises in the cases of road and rail transport: The estimation of the 1998 figures base on input data from the mid nineties. Thus, they can also be used for 1996. Though this is a simplification one should keep in mind that it is unlikely that substantial changes in the noise exposure situation occur within the very short period of two years. Against this background and the probable fact that the difference between the two years is much smaller than the uncertainty in the input data we renounce calculating 1996 figures for the noise costs.

Forecast methodology: The forecast offers similar data problems. And, two contrary processes might effect that the noise costs do not change significantly though the general conditions will be different in the year 2005:

- On the one hand, there are extensive realisation programmes of noise protection measures. In the case of rail, for example, about € 1.42 billion will be spent in the next years to realise noise protection measures (rolling stock, noise protection windows etc.). More than 250 000 people will profit from this extensive investment. Also for road and air transport, significant efforts will be made in the next decade to lower the annoyance by traffic noise.
- On the other hand, for all transport modes substantial increases in traffic volume are predicted (see the templates in the annex). Furthermore, the figures used for valuation grow with the GDP / capita between 1998 and 2005.

The overall effect is unclear. A serious estimate could only be made on the basis of a link by link analysis. Such an analysis is far beyond the scope of UNITE where a pragmatic approach has to be chosen to calculate the 1996 and 2005 figures.

In a study within the National Research Programme 41 Transport and Environment an estimate of the overall effects has been made (see Maibach et al., 1999). For rail transport, these estimates relies on the improvements that are to be achieved with the € 1.42 billion mentioned above. For road transport, it is a rough guess about plausible changes (two scenarios, 10% and 25% reduction of the number of houses/flats exposed to heavy traffic noise). The figures given in chapter 4 for road and rail transport rely on the assumptions taken in this study.

For aviation, no estimate for the year 2005 is made. The reason is that because of an agreement between Germany and Switzerland about air traffic to and from Zurich Airport made in 2001 the approach corridors and the number of aircrafts using the different corridors will change substantially. The results of these changes can't seriously be assessed at the moment.

3.5.4 Nature, Landscape and Further Environmental Effects

a) Overview of working steps

Except for the calculation of the barrier effect and repair costs of habitat losses for which a different approach is chosen for Switzerland, the methodology applied to determine the annual costs of the year of investigation (1998) follows the approach taken by INFRAS/IWW (2000) with the specification of the accounts approach for environmental costs by Bickel et al. (2000). According to this methodological approach, the costs of nature and landscape are defined as the "share of the accounting period at the total loss of ecological resources caused by the construction of transport infrastructure from a defined base year of accounting." The base year is set 1950 and should represent a state at which nature is considered more or less intact – with no crucial harm or damage due to transport infrastructure.

According to the accounts approach (Bickel et al. 2000), the following main estimation steps are to be elaborated:

1) Establishment of an infrastructure inventory,
2) Establishment of a biotope inventory for the reference year (1950) as well as for the accounting years,
3) Depreciation of lost habitats due to new infrastructure over time resulting in the calculation of the total costs.

For the calculation of the Swiss pilot accounts a biotope inventory meaning the types of natural areas affected (step 2) does not have to be established due to the fact that a different approach is chosen for the calculation of the habitat losses (see below).

The cost values used are characterised by the following items:
- cost categories,
- type of infrastructure built.

b) Cost categories

Following the recommendations given in Bickel et al. (2000) on the treatment of the costs of nature and landscape and the costs of soil and water pollution and due to the similarity of these environmental cost categories, they are considered jointly in the UNITE accounts.

The damages of nature and landscape according to cost categories are calculated by estimating the costs of compensation or repair of the originally natural land taken by building transport infrastructures. This includes the installation of new biotopes where natural areas are being destroyed through unsealing of sealed ground or cleaning of impaired soil and ground water and also the re-connection of cut habitats in case wild-life is hindered to migrate to other (natural) places by using its former migration corridors. Therefore, there are three relevant cost categories to be considered, all of which are calculated with the compensation or repair cost approach:

1. **Unsealing of sealed infrastructure areas:**
   Sealing effects are valued by a compensation cost approach, starting from the idea that every newly sealed area must be unsealed somewhere else. Thus the unsealing costs of sealed ground covered with transport infrastructure are estimated (Bickel et al. 2000).

2. **Decontamination of impaired soil and ground water alongside infrastructures:**
   The different pollutants of soil and ground water are considered jointly by applying a decontamination cost value per m^3 (repair cost approach). For soil contamination alongside or around transport infrastructures an average contamination depth of 20 cm and – depending on the type of infrastructure – a certain perimeter/stripe of contaminated soil are assumed (Bickel et al. 2000).

3. **Repair of habitat losses and deterioration for biodiversity:**
   Included are the loss of natural habitats and barrier effects caused by the existence of transport infrastructure. In the accounts approach for environmental costs (Bickel et al. 2000) it is suggested that the depreciation of lost habitats is estimated by using biotope inventories.

In the Swiss pilot accounts an alternative approach is chosen for the calculation of costs for habitat losses and deterioration of biodiversity. The Swiss approach is based on a recent experts' study (Vogelwarte Sempach, forthcoming) with an appropriate approach to estimate the barrier effects caused by transport infrastructure. For the calculation of the damage a repair cost approach is used which estimates the costs for establishing bridges and underpasses for migrating wildlife of different sizes. According to a recent Swiss study (Vogelwarte Sempach), the erection of animal passages over impassable roads such as motorways is by average necessary every 20 km of road in order to more or less guarantee the habitual animal migration for larger animals such as deer, lynx, wolf, fox, etc. Average costs are based on experiments regarding the width of the passages in order that the majority of animals will take advantage of them. According to experts (Vogelwarte Sempach), an optimal width would be 80–100 m. Thus the minimum width of 50 m (at which about half of the larger animals would still pass) has been taken into consideration for the calculation. The average cost for a 50 m wide animal bridge or underway passage is considered to amount to 4 million CHF (€ 2.5 million). For smaller animals such as reptiles and amphibians possibilities to cross large roads would have to be established in smaller intervals. Small pipes underpassing the motorways at every 1 km of road length would be appropriate to satisfy their needs for crossing the roads. The establishment of pipes is estimated at average costs of 10 000 CHF (= € 6 250) each (interval and cost estimation according to experts). At places where 50 m bridges or underpasses are taken into account (i.e. every 20 km), no additional pipes for smaller animals are considered.

This calculation of the lost habitats is only applied to the Swiss national roads (motorways, motor roads and mixed roads), as they may largely contribute to the barrier effects hindering the animal migration. It would also be applied to high-speed double track railways, of which there are none in Switzerland. All the smaller inter-urban and rural roads and the conventional tracks (with an assumed sealing factor of only 50%) are neglected in the habitat loss repair costs approach, since (according to railway experts) the barrier effect is considered minor compared to the larger national roads or high-speed tracks.

The tables in the following sections on the different transport modes give an overview about the methodology chosen for the calculation of the total costs of nature, landscape and further environmental effects.

As suggested in Bickel et al. (2000), we do not explicitly consider:

a) accidents and environmental health costs to the field of nature and landscape,

b) visual intrusion, to be considered as opportunity costs of nature and landscape from an anthropocentric point of view.

In contrast to the cost categories according to the accounts approach (Bickel et al. 2000), we do not consider the effects from winter maintenance on groundwater. According to a Swiss study (ASTRA, 1997) there is no considerable salt load to be identified in the groundwater as cause of winter services, at least not for quantitatively meaningful ground-water supplies and for local and moderate ground-water supplies. Based on a large abundance of linked results, there is sufficient proof given for this statement. Nevertheless, for ground water supplies with modest productivity and for spring water occurrences closely situated alongside transport facilities, in some cases problems with de-icing agencies can be faced under the following conditions:

– if winter maintenance has to be very intensive because of the importance and high altitude of the means of transport,
– if transport frequency is very high,
– if gain of spring water in limestone areas (karstland) is close to means of transport.

Further evidence that there are no considerable risks to be faced for ground water by using de-icing agencies is given in the study carried out by Juha Tervonen (2000).

Since there is no important international waterborne transport in Switzerland, waterborne infrastructure such as harbours can be neglected.

Types of Infrastructure: In the following paragraphs, a more detailed methodology per mode of transport is described for the years taken into account. The most important considerations and working steps are shown in the tables below.

c) Road

The cost parameters and the general data for the road infrastructure and nature, landscape and soil parameters are shown in the following table:

Table 3-31: Road infrastructure categories and general considerations as basis for the calculation of the environmental costs of nature, landscape and further environmental effects

Area for road infrastructure by nature, landscape and further environ. effects	Original width m	Compens. Factor %	Sealing factor %	Additional impaired width m
Motorway > 20 m	29	100%	100%	10
Motorway < 20 m	9	100%	100%	10
Inter-urban/Rural roads > 9 m	15	100%	100%	10
Inter-urban/Rural roads < 9 m	8	100%	100%	10

The type of road network and the calculated average cost units are given for the years 1998, 1996 and 2005 in the paragraphs and tables below.

Base Year 1998: In case of **sealed and impaired soil**, the costs for the reporting year are determined by subdividing the total costs since the reference year (1950) by the respective number of years. We do not apply a discount rate on past costs caused to nature and landscape because no average life span of repaired soil and therefore no amortisation costs can be assumed. Further reasons against discounting rates are given in the German case study. Yet a PPP-Adjustment is necessary because the original repair cost figures for unsealing and soil decontamination are based on original German-specific figures in DM.

For the calculation of repair costs of **habitat losses** (barrier effect) and deterioration for biodiversity we apply an annuity of 4%, assuming an amortisation period of animal bridges, underpasses and pipes of 50 years and an average annual interest rate of 3% on today's prices (at factor costs).
The road infrastructure categories are listed in the figures below.

Table 3-32: Infrastructure characteristics 1998 for the road network

Infrastructure type 1998	Sealed area	Contaminated area	Network in ref. year	Network in account. year	Average annual network growth
	ha/km	ha/km	km	km	km
Motorway > 20 m	2.9	1.0	0	1 096	25.5
Motorway < 20 m	0.9	1.0	0	369	8.6
Inter-urban/Rural roads > 9 m	1.5	1.0	0	0	0.0
Inter-urban/Rural roads < 9 m	0.8	1.0	16 832	18 176	31.3
Road total	32.6	19.0	16 832	19 641	

Backcast methodology: The methodological approach does not differ from the approach used for the calculation of the base year. Infrastructure data for 1996 and a GDP/PPP-adjustment for referencing the base year and the currency adjustment are applied.

Table 3-33: Infrastructure characteristics 1996 for the road network

Infrastructure type 1996	Sealed area	Contaminated area	Network in ref. year	Network in account. year	Average annual network growth
	ha/km	ha/km	km	km	km
Motorway > 20 m	2.9	1.0	0	1 121	22.4
Motorway < 20 m	0.9	1.0	0	333	6.7
Inter-urban/Rural roads > 9 m	1.5	1.0	0	0	0.0
Inter-urban/Rural roads < 9 m	0.8	1.0	16 832	18 224	27.8
Road total	32.6	19.0	16 832	20 405	

Forecast methodology: Future damages are hence valued as high as damages caused today. This implies also the assumption that the average damage to resources caused by the installation of infrastructure projects did not differ in general and that the average costs per additional square metre of transport assets constructed is equal over time. Further, it is not possible to assume a certain amortisation period – and therefore a specific annuity – for the unsealing or decontamination of sealed or impaired ground. Yet a GDP/PPP adjustment is included in the calculation. The following figure shows the prediction of the Swiss road infrastructure development as basis for the calculation of the repair costs for soil, nature and landscape.

Table 3-34: Infrastructure characteristics 2005 for the road network

Infrastructure type 2005	Sealed area	Contami-nated area	Network in ref. year	Network in account. year	Average annual network growth
	ha/km	ha/km	km	km	km
Motorway > 20 m	2.9	1.0	0	1 132	22.6
Motorway < 20 m	0.9	1.0	0	359	7.2
Inter-urban/Rural roads > 9 m	1.5	1.0	0	0	0.0
Inter-urban/Rural roads < 9 m	0.8	1.0	16 832	17 968	22.7
Road total	32.6	19.0	16 832	19 459	

d) Rail

Table 3-35: Railways infrastructure categories and general considerations as basis for the calculation of the environmental costs of nature, landscape and further environmental effects

Area for rail infrastructure by nature, landscape and further environ. effects	Original width	Compens. Factor	Sealing factor	Additional impaired width
	m	%	%	m
High speed (double track)	13	100%	100%	10
Conventional (double track)	13	100%	50%	10
Conventional (single track)	6	100%	50%	10

Base year 1998 and backcast methodology: For the railways no different approach than that for the road transport has to be chosen. There are no high-speed tracks in Switzerland. The railways infrastructure categories are listed in the figures below.

Table 3-36: Infrastructure characteristics 1998 for the railways network

Infrastructure type 1998	Sealed area	Contami-nated area	Network in ref. year	Network in account. year	Average annual network growth
	ha/km	ha/km	km	km	km
High speed (double track)	1.3	1.0	0	0	0.0
Conventional (double track)	0.7	1.0	1 111	1 610	10.4
Conventional (single track)	0.3	1.0	3 655	3 059	0.0
Rail total	2.3	3.0	4 766	4 670	

Table 3-37: Infrastructure characteristics 1996 for the railways network

Infrastructure type 1996	Sealed area	Contami-nated area	Network in ref. year	Network in account. year	Average annual network growth
	ha/km	ha/km	km	km	km
High speed (double track)	1.3	1.0	0	0	0.0
Conventional (double track)	0.7	1.0	1 111	1 599	10.6
Conventional (single track)	0.3	1.0	3 655	3 077	0.0
Rail total	2.3	3.0	4 766	4 676	

Forecast methodology: The following figure shows the prediction of the Swiss railways infrastructure development as basis for the calculation of the repair costs for soil, nature and landscape.

Table 3-38: Infrastructure characteristics 2005 for the railways network

Infrastructure type 2005	Sealed area	Contaminated area	Network in ref. year	Network in account. year	Average annual network growth
	ha/km	ha/km	km	km	km
High speed (double track)	1.3	1.0	0	0	0.0
Conventional (double track)	0.7	1.0	1 111	1 657	9.9
Conventional (single track)	0.3	1.0	3 655	2 929	0.0
Rail total	2.3	3.0	4 766	4 586	

e) Aviation

Base year 1998 and backcast methodology 1996: For the calculation of the unsealing and soil decontamination costs for the aviation sector the international/national and regional airports, and – in the Swiss pilot accounts – also the sealed airstrips are considered.

For all the airports the unsealing and compensation costs are calculated. Unlike suggested in Bickel et al. (2000), there are no compensation costs for habitat losses taken into account in the field of aviation in the Swiss pilot accounts. Firstly, we consider that – similar to the railway tracks – the airports in Switzerland cause no significant barrier effect for wildlife migration or at least barrier effects are not as severe as they are considered for the motorways (for which compensation measures are accounted). Even the largest Swiss airport (Unique Airport of Zurich) covers valuable natural biotopes within its total area, some of which is actual under national protection. Secondly, the extension of the sealed area of the Zurich airport from 316 ha in 1998 to a total of 359 ha in the year 2005 will be compensated with different measures[29] to be taken within the near airport area. These measures largely compensate the lost habitats.

The unsealing and decontamination costs are the same as described under the road chapter. The size of the sealed area per national airport is the average of the three (inter)national airports Zurich Unique Airport, Geneva and Basle-Mulhouse. The latter is located outside the Swiss border in France but still has to be considered for the environmental effects on Switzerland. The average sealed area of regional airports is estimated to be 80 ha according to the accounts methodology (Bickel et al. 2000). For sealed airstrips an average size of 10 ha is assumed for Switzerland. For all the airports and airstrips only the sealed areas and a theoretical 50 or 25 meter radius of impaired soil are taken into account (see table below). In practise, the total airport area is extended and intersected with unsealed ground. In case of the Zurich Unique airport, the largest airport in Switzerland with a sealed area of 316 ha in the year 1998, there are lots of habitats and biotopes valuable to nature. For these reasons no repair costs of habitat losses has be taken into account. The following figure shows the system boundaries and the assumptions taken into account.

29 The compensation of nearly 5 ha protected natural habitats include - in four different projects - measures such as the revitalisation of river banks in a 80 ha wetland area or the creation of new species-rich meadows in an old gravel pit. The Zurich Unique Airport is prepared to pay 20 mill. CHF (12.3 mill. €) for those compensation measures.

Table 3-39: Aviation infrastructure categories and general considerations as basis for the calculation of the environmental costs of nature, landscape and further environmental effects, 1996 and 1998

Area for infrastructure by nature, landscape and further environ. effects	Average size	Compens. Factor	Sealing factor	Additional impaired width
	ha	%	%	m
National airports	174	100%	100%	50
Zurich Unique Airport	*316*	*100%*	*100%*	*50*
Genf-Cointrin	*130*	*100%*	*100%*	*50*
Basel-Mulhouse	*77*	*100%*	*100%*	*50*
Regional airports	40	100%	100%	25
Airstrips with sealed runways	10	100%	100%	25

To calculate the annual growth rate of the sealed area, the newly built airports/airstrips since the reference year 1950 as well as the additional sealed area of the airports/airstrips already existing in the base year are taken into account. The average growth rate of the sealed area of the largest national Airport (Zurich Unique) can be calculated for the year 1998 because the sealed area of the base year 1950 is known. Thus we assume the same growth rate (from 1950 to 1998) for the other two national airports. For the smaller regional airports and the airstrips we have no evidence about how large the sealed area was in the base year 1950. Thus we assume that in 1950 half of the sealed area of 1998 already existed. With these assumptions the average annual growth rate of the sealed airport areas can be estimated for the years 1998 and 1996:

Table 3-40: Infrastructure characteristics 1996 and 1998 for the airports and sealed airstrips

Infrastructure type 1996/1998	Sealed area	Contaminated area	Network in ref. year	Network in account. year	Network in ref. year	Network in account. year
	ha	ha	No. airports	No. airports	ha	ha
National airports	174.3	26.4	3.0	3.0	141	523
Regional airports	40.0	6.3	9.0	10.0	180	400
Airstrips with sealed runways	10.0	3.2	7.0	17.0	35	170
Aviation Total	224.3	35.9	19.0	30.0	356	1 093

Forecast methodology: The number of airports and airstrips in 2005 is estimated by taking into account an average annual network growth. The sealed area in the year 2005 is only known for the largest (inter)national airport of Zurich. Similar to the calculation for the years 1998 and 1996 the same growth rate as for the Zurich airport is assumed for the other two national airports. For all the regional airports and local airstrips we assume no additional increase of the sealed areas since 1998. Therefore, the average annual growth rate for these smaller airports/airstrips is estimated to be slightly smaller for the year 2005 than it is for the years 1998/1996 – in reference of the base year of 1950. For regional airports and sealed airstrips the same average size is considered as for the years 1996 and 1998. For the airports Zurich Unique and Basle-Mulhouse the actual area growth scenario is known (359 ha sealed area in Zurich and about 95 ha in Basle-Mulhouse in the year 2005), whereof for the Geneva airport the same growth rate of the sealed area as for the Basle-Mulhouse airport until 2005 is assumed (+13% area increase since 1998). The adjustment of the calculated unsealing and decontamination costs are already described in the road section.

Table 3-41: Infrastructure characteristics 2005 for the airports and sealed airstrips

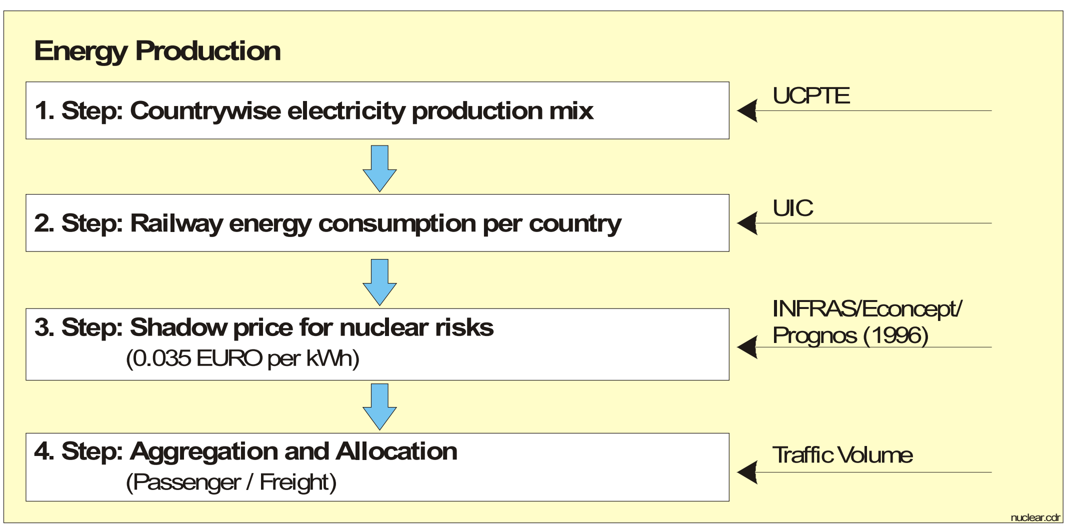
Infrastructure type 2005	Sealed area	Contami-nated area	Network in ref. year	Network in account. year	Network in ref. year	Network in account. year
	ha	ha	No. airports	No. airports	ha	ha
National airports	200.5	28.3	3.0	3.0	141	601
Regional airports	40.0	6.3	9.0	10.0	180	400
Airstrips with sealed runways	10.0	3.2	7.0	18.0	35	180
Aviation Total	250.5	37.8	19.0	31.0	356	1 181

3.5.5 Nuclear Risk

a) Overview of working steps

For the calculation of nuclear risk costs the electricity consumption of different means of transport is multiplied with a shadow factor as described in the accounts approach. For the calculation of the nuclear power consumption, the specific electricity production mix of the SBB or for Switzerland is taken. The total power consumption for the different modes of transport is to date available until 1997 (except for the SBB for which it is known until 1998). For smaller railway companies, urban trolley buses and tramways the 1997 data is taken as approximate estimation for the accounting year 1998.

Table 3-42: General procedure (shadow price approach) for the estimation of external costs of nuclear risks (INFRAS/IWW (2000))



According to a study of Zweifel and Umbricht (2000), summarised in Bickel et al. (2000), the shadow factor is set at CHF 0.025 or € 0.015 per kWh nuclear power.
Relevant modes of transport in regard to the electricity consumption are the urban public transport systems (trolley buses and tramways) and the railway companies (the federal railway company SBB and the network of the smaller and private KTU companies).

b) Public transport/Road

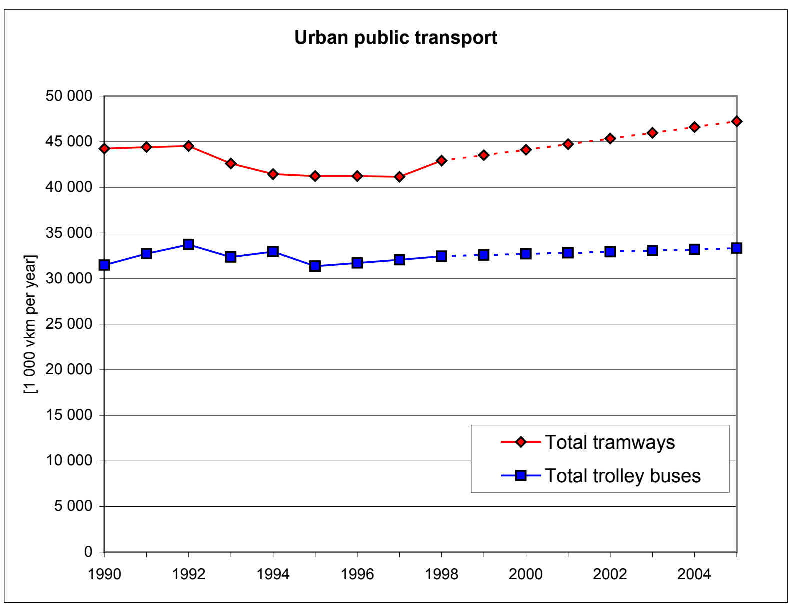
Base year 1998 and backcast methodology: For road-based electricity-consuming means of transport, i.e. trolley buses and tramways, the annual electricity consumption is multiplied with the share of nuclear power according to the average Swiss power mix (see the tables in the sections 2.6.1 and 3.5.1)[30]. The trolley buses and tramways have an annual nuclear power consumption for the accounting years as it is shown below. The 1998 figures reflect the actual 1997 consumption because the latest statistics have not yet been published.

Table 3-43: Nuclear power consumption of trolley buses and tramways for the years 1996, 1998 and 2005.

Means of transport		Total power consumption [1000 kWh]			Nuclear power consumption [1000 kWh]		
		1996	1998	2005	1996	1998	2005
Urban public transport	Trolley buses	87 316	88 461	90 437	37 546	35 384	31 924
	Tramways	124 107	124 823	145 951	53 366	49 929	51 521
Total		1 897 423	2 366 611	2 587 614	530 922	288 483	419 633

Forecast methodology: The electricity consumption of electricity-driven urban buses and trams is calculated according to a trend extrapolation of the annual vehicle kilometres of tramways and trolley buses.

Table 3-44: Trend extrapolation of the annual vehicle kilometres of urban tramways and trolley buses until the year 2005



The annual power consumption for the forecast years is estimated as average consumption per vehicle kilometre (kWh/vkm) of the years 1990 to 1997 (1998 consumption has not yet been known). Since we have no evidence about the nuclear share for the year 2005, we assume a nuclear share according to the Swiss electricity production mix of 1999 for all years between 1999 and 2005.

30 There are no figures available of the exact electricity mix and specific electricity consumption of each of the communities' trolley buses and tramways.

c) Rail

Base year 1998 and backcast 1996: For the railways, the electricity consumption and the electricity production mix of the SBB – the largest and federal railway company – is available (SBB, 1999). Since also part of the electricity used by other smaller and regional railway companies (KTU) is ordered via the SBB power network and because for the remaining power consumption an electricity production mix similar to that of the SBB (with an overwhelming part of hydro power) can be assumed, the SBB electricity production mix is also for the smaller and regional railway companies taken into account. The specific SBB electricity production mix is an aggregated mix calculated of the monthly consumed electricity. As a consequence of the consideration of an annual overall consumption figure there is almost no – or depending on the year even no – nuclear power share resulting. This is because the export of hydro power in the summer months exceeds the imports of nuclear power in the winter months. With calculation of the specific electricity mix from an over the year aggregation, the nuclear power share of rail-based transport systems is small or even zero.

Table 3-45: Nuclear power consumption of the Swiss railway companies (the SBB and the smaller railways) for the years 1996, 1998 and 2005

Means of transport		Total power consumption [1000 kWh]			Nuclear power consumption [1000 kWh]		
		1996	1998	2005	1996	1998	2005
Railways	SBB	1 686 000	1 746 000	2 021 682	440 010	164 737	289 068
	KTU	413 719	407 327	329 544	107 972	38 432	47 120
Total		1 897 423	2 366 611	2 587 614	530 922	288 483	419 633

Forecast 2005: For the forecast of the nuclear power consumption in the year 2005, figures are supplied by the SBB (2001) estimating both the electricity consumption and the power mix for the year 2005. A nuclear power share of almost 15% (based on rough and uncertain estimations of the SBB considering scenario calculations) is assumed. Since the hydro power supply – and therefore the nuclear power consumption for the remaining electricity use – is strongly differing from year to year, the estimated nuclear power share for the year 2005 is very vague. Nevertheless it is assumed to be much higher for the coming years because the overall electricity consumption for the SBB is estimated to increase for about 16% from the year 1998 to 2005 and because not all of the additional electricity consumption can be covered with hydro power. For the smaller regional railway companies (KTU), an extrapolation of the power consumption (based on an index with kWh/brutto-tkm) until 2005 has to be underlined. The same nuclear power share is taken for 2005 as for the SBB.

3.6 Taxes, Charges and Subsidies

Since data availability of this category is linked to the infrastructure costs and to the supplier operating costs, most of the methodological assumptions are shown in the respective chapters:

- Infrastructure charges and taxes by type of revenue are reflected in the respective infrastructure accounts, The estimation of hidden subsidies is based on information of historic grants provided by the state.
- Supplier operating revenues and subsidies are reflected in the respective supplier costs accounts for rail and road based public transport. The estimation of hidden subsidies is based on information of interest subsidies (provision of lower interest rate, especially for rolling stock).

4 The Results in Detail

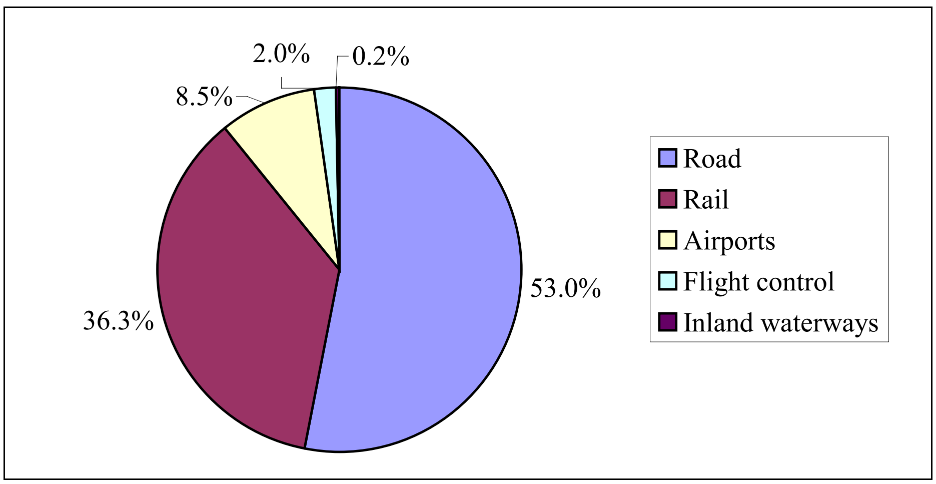
4.1 Infrastructure Costs

4.1.1 Overview

The methodology for infrastructure costs according to Link at al. (2001) proposed a differentiation between infrastructure and the operating level for all modes. This was not possible for public transport, airports and ports (inland waterways). The figures for public transport are therefore shown as an aggregate within the chapter supplier operating cost. Looking at the figures of airports it is obvious that on cost and on revenue side some categories can be assigned without problems to infrastructure or operating, but others cannot. Therefore, we show the aggregated figures for airports in the infrastructure chapter. The same applies for inland waterways. Additionally, for all modes a split into variable and fixed costs was requested. In the following accounts only total costs are shown. Basic information for all modes was not detailed enough for the requested split.

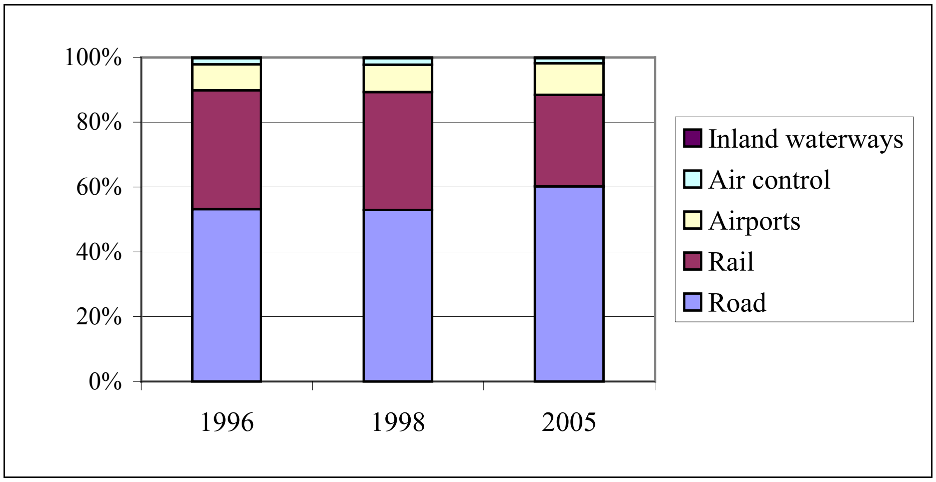
The following two figures show an overview of the total infrastructure cost of all transport modes in order to give a general impression before going into detail of every single transport mode.

Table 4-1: Infrastructure costs overview 1998: Split of total infrastructure costs between the different transport modes, in %



In 1998, more than half of the total infrastructure cost incurred on the road, roughly one third is caused by rail infrastructure, infrastructure air is responsible for a little more than 10% of total infrastructure costs and inland waterways play a very minor role. In Switzerland, the total infrastructure costs amount to € 7.6 billion in 1998 and to € 9.2 billion in 2005.

Table 4-2: Infrastructure costs overview: Change in the composition of total infrastructure costs between 1996 and 2005, in %



Comparison of the composition of total infrastructure costs between the three years shows that the share of the infrastructure cost road is increasing, while the share of rail is diminishing due to a narrower definition of the core infrastructure in 2005. Because of the strong growth of air traffic, the share of infrastructure cost of airports is also rising. The share of the infrastructure costs of inland waterways only amounts to 0.2% of total infrastructure costs.[31]

4.1.2 Road

Total infrastructure costs for the base year 1998 are presented in the table below.

Table 4-3: Infrastructure costs road 1998, in € million, 1998 prices

1998	Cost categories					
	Current costs I	Current costs II	Capacity costs	Load related costs I	Load related costs II	Total costs
Vehicle categories	Maintenance	Administration, signalisation, traffic control	Capital costs non load related	Non axle weight related maintenance costs	Axle weight related maintenance costs	
Mopeds	3.31	2.26	3.35	0.00	0.00	8.93
Motorcycles	15.20	20.81	45.72	0.00	0.00	81.72
Cars	390.62	534.90	2 110.85	0.00	0.00	3 036.37
Coaches	1.07	1.47	10.21	9.03	6.00	27.78
Buses	2.08	2.85	23.43	17.53	11.65	57.54
LGV	32.27	44.19	184.21	0.00	0.00	260.67
Trucks	15.22	20.84	139.13	100.00	88.31	363.50
Trailer	6.13	8.40	44.81	6.09	10.27	75.69
Tractor for semi-trailer	3.79	5.19	24.95	14.33	15.48	63.74
Semi-trailer	2.99	4.09	23.03	11.20	12.64	53.95
Total	**472.69**	**645.00**	**2 609.68**	**158.18**	**144.34**	**4 029.88**

31 This small share is not visible in the chart.

Table 4-4: Infrastructure costs road 1996, in € million, 1998 prices

1996	Cost categories					
	Current costs I	Current costs II	Capacity costs	Load related costs I	Load related costs II	Total costs
Vehicle categories	Maintenance	Administration, signalisation, traffic control	Capital costs non load related	Non axle weight related maintenance costs	Axle weight related maintenance costs	
Mopeds	3.85	2.52	3.90	0.00	0.00	10.26
Motorcycles	14.24	18.71	42.65	0.00	0.00	75.60
Cars	397.63	522.36	2 131.72	0.00	0.00	3 051.71
Coaches	1.11	1.46	10.65	6.86	5.64	25.72
Buses	2.21	2.90	24.92	14.05	11.39	55.48
LGV	30.41	39.94	172.23	0.00	0.00	242.58
Trucks	16.20	21.28	147.75	100.43	97.45	383.11
Trailer	5.91	7.77	42.99	2.84	6.51	66.02
Tractor for semi-trailer	3.74	4.91	24.47	17.66	15.59	66.36
Semi-trailer	2.89	3.79	22.32	4.63	7.66	41.28
Total	**478.18**	**625.63**	**2 623.58**	**146.48**	**144.25**	**4 018.10**

Table 4-5: Infrastructure costs road 2005, in € million, 1998 prices

2005	Cost categories					
	Current costs I	Current costs II	Capacity costs	Load related costs I	Load related costs II	Total costs
Vehicle categories	Maintenance	Administration, signalisation, traffic control	Capital costs non load related	Non axle weight related maintenance costs	Axle weight related maintenance costs	
Mopeds	3.72	2.70	3.11	0.00	0.00	9.53
Motorcycles	18.77	27.31	46.05	0.00	0.00	92.13
Cars	613.14	892.46	2 683.20	0.00	0.00	4 188.79
Coaches	1.75	2.55	13.77	10.27	6.21	34.56
Buses	2.44	3.56	22.60	14.76	8.80	52.17
LGV	46.07	67.05	213.45	0.00	0.00	326.56
Trucks	30.03	43.71	227.97	177.22	129.99	608.92
Trailer	9.61	13.99	57.19	4.39	7.40	92.58
Tractor for semi-trailer	5.26	7.65	28.50	25.06	15.98	82.45
Semi-trailer	5.41	7.87	34.23	8.23	10.01	65.75
Total	**736.19**	**1 068.85**	**3 330.07**	**239.94**	**178.39**	**5 553.44**

Between 1996 and 1998, infrastructure costs road remained almost unchanged. Until 2005, a significant increase is to be expected. This is mainly due to higher maintenance costs, the construction of new roads according to the fifth long-term construction program of the public authorities and rising capacity costs. The load-related costs show an increase because of the ongoing growth of freight transportation on the road and because of the introduction of a new maximum weight limit for lorries in Switzerland (40 tonnes).

Table 4-6: Infrastructure costs road per vkm, in €, 1998 prices

Vehicle categories	1996	1998	2005
Mopeds	0.03	0.03	0.03
Motorcycles	0.05	0.05	0.06
Cars	0.07	0.06	0.08
Coaches	0.23	0.25	0.24
Buses	0.25	0.27	0.26
LGV	0.08	0.08	0.09
Trucks	0.24	0.23	0.25
Trailer	0.11	0.12	0.12
Tractor for semi-trailer	0.18	0.16	0.19
Semi-trailer	0.14	0.18	0.15

The table above shows the infrastructure costs road per vehicle kilometre. These costs remain almost constant for most of the vehicle categories between 1996 and 2005.

For 1996 and 1998 we used the official data and took all the relevant studies into account for the forecast. Therefore, no deviation to other results occurs.

4.1.3 Rail

Infrastructure costs rail have been divided into passenger transport related and freight transport related costs. The Swiss railway companies only provide overall infrastructure figures. The separation has been done ourselves by using the same indicator as in Germany: Axle kilometre. In Switzerland the relation between axle kilometre in passenger transport and in freight transport is about 2:1 (BFS, 2000).

Table 4-7: Infrastructure costs rail, in € million, 1998 prices

	1996		1998		2005	
Cost categories	Passenger transport	Freight transport	Passenger transport	Freight transport	Passenger transport	Freight transport
Material	60	31	59	31	46	24
Personnel	668	350	661	347	515	270
Other running costs	394	206	390	204	304	159
VAT (non deductable)	32	17	32	17	25	13
Cross-sectoral costs	148	78	146	77	114	60
Special costs	30	16	30	16	23	12
Running costs	**1 332**	**698**	**1 319**	**692**	**1 027**	**539**
Depreciation	237	124	242	127	341	179
Interest	247	129	252	132	341	179
Total costs	**1 816**	**952**	**1 812**	**950**	**1 710**	**896**

Looking at the development of costs it is obvious that there is a decline until 2005. The reason is mainly a question of the definition of infrastructure used by the railway companies. Until 1998, the definition is widespread and takes into account e.g. all the railway stations (with restaurants, etc.). Since 2000, more and more railway companies make an effort to define a so-called core infrastructure, covering only the really essential parts for the processing of rail passenger and freight transport. This development is connected as well with declining running costs. Capital costs are going to increase after 1998 because major railway infrastructure investments will be made (e.g. 'Bahn 2000'), and the total of the asset value of infrastructure will therefore increase significantly.

All the figures above are shown in factor costs, therefore no VAT should be included. But the infrastructure divisions of the railway companies are faced with non-deductible VAT, and this cost factor has to be shown within the factor costs as well.

The most important railway infrastructure project - the new alpine transversal (NEAT) - is not yet included in the figures above. This investment amounts to € 9.1 billion, spread over a construction period from 2000 until 2016, and aims at building two new tunnels through the Alps mainly for freight transport. Two public companies have been founded for processing the construction. It is not yet decided who will be the owner of these companies (and of the two tunnels) in the end. Therefore, the NEAT is not included in the account infrastructure cost rail. Just to give an impression of the order of magnitude of these investments: In 2005, interest payments for loans will amount to € 335 million.

Table 4-8: Infrastructure costs rail per train-km, in €, 1998 prices

	1996		1998		2005	
	Passenger transport	Freight transport	Passenger transport	Freight transport	Passenger transport	Freight transport
Costs per train-km	13.95	33.29	13.75	33.11	12.63	29.93

The table above shows the infrastructure costs rail per train kilometre. For both passenger transport and freight transport costs per train kilometre diminishes over time. This is mainly due to an increase in productivity. The infrastructure costs for freight transport is almost 2.5 times higher than infrastructure costs for passenger transport.

A comparison with former results from other studies is not possible, because for 1996 and 1998 we used official data and built a new rail account, separating for the first time between transport services and infrastructure. In the aggregate the figures correspond with the official numbers. Therefore no deviation to other results occur.[32]

4.1.4 Aviation

Infrastructure costs of aviation (national airports and national flight control) in Switzerland are shown in the tables below.

32 Switzerland is revising its national rail account for the time being. The approach used here is consistent with a respective pilot study (INFRAS, 2000).

Table 4-9: Infrastructure costs aviation, national airports, in € million, 1998 prices

Cost categories	1996	1998	2005
Current costs	229.40	245.15	311.27
Taxes and charges	10.75	9.83	15.48
Personnel	129.62	137.39	176.61
Extraordinary costs	12.78	9.84	13.64
Running costs	**382.55**	**402.21**	**516.99**
Depreciations	136.97	160.09	240.49
Interest rates	87.31	87.73	141.98
Total costs	**606.83**	**650.02**	**899.47**

Table 4-10: Infrastructure costs aviation, flight control, in € million, 1998 prices

Cost categories	1996	1998	2005
Current costs	39.48	40.45	38.49
Taxes and charges	0.00	0.00	0.00
Personnel	84.57	86.65	82.45
Extraordinary costs	8.37	8.58	8.16
Running costs	**132.42**	**135.68**	**129.10**
Depreciations	16.18	16.57	15.77
Interest rates	2.00	2.05	1.95
Total costs	**150.59**	**154.30**	**146.82**

The figures for aviation are differentiated between the national airports and the flight control. The national airports show a strong increase of infrastructure costs until 2005. Main reason is the building of the fifth construction stage at Airport Zurich (third terminal, railway connection between the terminals, etc.) with construction costs of overall € 1.3 billion (1996 – 2005). This leads to higher running costs because of an increasing number of flights and to increasing capital costs due to the rise in the asset value of the airports.

Costs for the flight control in Switzerland will remain quite constant and even decline slightly until 2005. This corresponds with the development between 1998 and 2000 and shows increasing efficiency.

A comparison with former results from other studies is not possible, because no other studies or official figures exist for the account we made. For 1996 and 1998, we used the official business accounts. The forecast is made on the basis of the latest forecast of flight movements and the official investment plans. No official airport account exists in Switzerland. Therefore, no deviation to other results occurs.

4.1.5 Inland Waterways

After stagnation of the infrastructure costs of inland waterways (only Rhine ports covered) between 1996 and 1998, an increase of the costs will take place until 2005. This is due to infrastructure enlargement in the first years of the new millennium resulting in higher capital costs. The extension will enable the ports to clear more traffic and to achieve a higher turnover. This higher turnover is reflected in the increase of the running costs in the table above.

Table 4-11: Infrastructure costs inland waterways, in € million, 1998 prices

Cost categories	1996	1998	2005
Administration	0.42	0.44	0.68
Personnel	2.38	2.21	3.44
Maintenance	1.04	1.03	1.60
Energy	0.13	0.15	0.24
Other	3.71	3.90	6.06
Running costs	**7.68**	**7.73**	**12.01**
Depreciation	2.18	2.18	3.27
Interest	0.11	0.10	0.00
Total costs	**9.96**	**10.01**	**15.28**

A comparison with former results from other studies is not possible, because no other studies or official figures exist for the account we made. For 1996 and 1998, official business accounts were used. No official port account exists in Switzerland. Therefore, no deviation to other results occurs.

4.2 Supplier Operating Costs

4.2.1 Rail

The tables below present supplier operating costs in rail transport in Switzerland in 1996 and 1998 and a forecast for 2005 (total and average costs).

Table 4-12: Supplier operating costs of rail 1998, 1996 and 2005, in € million, 1998 prices

	1996			1998			2005		
Cost category	**pass.**	**freight**	**Total**	**pass.**	**freight**	**Total**	**pass.**	**freight**	**Total**
Material, goods, services	142	51	193	141	50	191	115	42	156
Personnel	1 047	317	1 364	1 037	314	1 350	846	261	1 107
Other running costs	116	139	255	115	138	253	94	115	208
VAT	14	2	17	14	2	16	12	2	13
Cross-sectoral costs	394	243	636	390	240	630	318	200	518
Special costs	1	0	1	1	0	1	1	0	1
Running Costs	**1 713**	**752**	**2 465**	**1 697**	**744**	**2 441**	**1 384**	**620**	**2 004**
Depreciation	112	26	138	112	26	138	97	27	124
Interest	188	102	290	191	99	290	169	92	261
Total Costs	**2 014**	**880**	**2 894**	**1 999**	**870**	**2 869**	**1 651**	**739**	**2 389**
Revenues	1 477	800	2 278	1 441	750	2 190	1 389	756	2 145
Subsidies	675	74	749	586	73	659	607	66	673

Table 4-13: Average supplier operating costs of rail 1998, 1996 and 2005, in €/train-km, 1998 prices

	1996			1998			2005		
Cost category	**pass.**	**freight**	**Total**	**pass.**	**freight**	**Total**	**pass.**	**freight**	**Total**
Average Costs	15.5	30.8	-	15.2	30.3	-	12.2	24.7	-

Supplier operating costs in rail transport decline from 1996 to 1998 slightly, whereas by 2005, a decrease of around 18% has been estimated. The reduction is mainly caused by an estimated higher efficiency of the personnel and an increase of productivity during this period. Another reason for lower costs are expected improvements of track management.

The calculation of operating costs in 2005 is based on the mid term plan of the SBB. If and in which range the herein predicted cost reduction is realistic could not be judged completely. In 2000 e.g., personnel costs have slightly risen again for the first time in the last years, although staff numbers were reduced during the same period. On the other hand, revenues will decrease slightly from 1998 to 2005. The main reason for this development is the still increasing number of long term pass holders leading to lower revenues per passenger.

Another critical point is the inclusion of investments in new rolling stock which was not foreseeable at the time the mid term plan was carried out. Latest developments show that at least SBB still invest a significant amount in the improvement of rolling stock. In co-operation with DB and ÖBB, around 140 tilting trains have been tendered in 2001.

Average supplier operating costs remained steady between 1996 and 1998, while a slight decrease is predicted for 2005. Transport performance will increase in the same period from 130 mill. train-km (passenger, 1996), 28 mill. train-km (freight 1996), respectively, to 135 mill. train-km/30 mill. train-km (in 2005).

4.2.2 Road Based Public Transport

The table below presents supplier operating costs of public transport services in 1996, 1998 and a forecast for 2005. The category 'road based public transport' includes hereby urban as well as regional public transport services.[33]

33 Modes in urban public transport: tramways, buses, trolley buses
Modes in regional public transport: buses

Table 4-14: Supplier operating costs of road based public transport 1996, 1998and 2005, in € million, 1998 prices

	1996			1998			2005		
Cost category	Reg. PT.	Urb. PT	Total	Reg. PT.	Urb. PT	Total	Reg. PT.	Urb. PT	Total
Personnel costs	217	528	745	199	469	668	211	479	690
Material, Goods, Services	271	197	468	237	178	416	251	182	433
Repair, Replacement costs	15	12	27	1	12	13	1	12	13
Other costs	0	0	0	5	0	5	0	0	0
Running costs	**504**	**737**	**1 241**	**442**	**659**	**1 101**	**467**	**673**	**1 140**
Depreciation	41	84	125	41	80	121	44	82	125
Financial costs	12	58	70	9	39	48	10	40	49
Total costs	**557**	**879**	**1 435**	**492**	**778**	**1 270**	**521**	**795**	**1 316**

Table 4-15: Average supplier operating costs of road based public transport 1996, 1998 and 2005, in €/vkm, 1998 prices

	Total costs in € mill.			**Vehicle-km**[1)] in mill. vkm			**Average costs** €/vkm		
	1996	**1998**	**2005**	**1996**	**1998**	**2005**	**1996**	**1998**	**2005**
Urban public transport	879	778	795	119.3	124.4	131	7.37	6.25	6.07
Regional public transport	557	492	521	147.3	146.8	151.2	3.78	3.35	3.45

1) Vehicle-km in urban public transport include vkm of tramways, trolley buses and buses.

The development of supplier operating costs between 1996 and 1998 shows a noticeable decrease of around 11.5% (or € 165 mill.). This decrease is mainly based on the introduction of competitive elements in urban and regional public transport which was the aim of the revised railway law introduced in 1996. As a consequence, some services have been submitted to a tendering procedure which lead to a reduction of subsidies for those services.

As already described in section 3.2.2, an ongoing decline of supplier operating costs in public transport is for several reasons not very likely. In connection with the slight increase of vkm of tramways and buses, total supplier operating costs in 2005 will rise by 3.6% (in comparison with 1998). Again, in order to forecast passenger numbers and vkm in 2005, only a rough estimate has been carried out. While doing this, the most critical point was the official public transport statistics which lack methodological consistency regarding the calculation of passenger numbers during the last 10 years.

4.3 Congestion Costs

The following tables show the results for congestion costs in road, rail and air transport in Switzerland for 1998, 1996 and a 2005 forecast.

Table 4-16: Congestion costs 1998, in € million, 1998 prices

	Additional costs due to disturbed traffic or small delays			Additional costs due to congested traffic or heavy delays		
	Total	Time	Fuel	Total	Time	Fuel
Road Traffic						
- Individual passenger transport	170.1	164.9	5.2	380.1	368.6	11.5
- Public passenger transport	53.4	53.4	-	10.4	10.4	-
- Freight Transport	-	-	-	36.8	34.7	2.1
Rail Traffic						
- Passenger Federal Railways	-	-	-	51.2	51.2	n.a.
- Passenger: other railways	-	-	-	7.0	7.0	n.a.
- Total Passenger	-	-	-	58.2	58.2	n.a.
- Freight services	-	-	-	6.4	6.4	n.a.
Air traffic						
- Passenger: Scheduled flights	-	-	-	112.8	112.8	n.a.
- Passenger: Charter flights	-	-	-	19.0	19.0	n.a.
- Total Passenger	-	-	-	131.8	131.8	n.a.
- Freight services	-	-	-	n.e.	n.e.	n.a.
TOTAL						
- Road	223.5	218.3	5.2	427.3	413.7	13.6
- Rail	-	-	-	64.6	64.6	-
- Aviation	-	-	-	131.8	131.8	-

Table 4-17: Congestion costs 1996, in € million, 1998 prices

	Additional costs due to disturbed traffic or small delays			Additional costs due to congested traffic or heavy delays		
	Total	Time	Fuel	Total	Time	Fuel
Road Traffic						
- Individual passenger transport	165.2	160.3	4.9	339.0	329.1	9.9
- Public passenger transport	57.9	57.9	-	10.6	10.6	-
- Freight Transport	-	-	-	25.2	23.7	1.4
Rail Traffic						
- Passenger Federal Railways	-	-	-	48.4	48.4	n.a.
- Passenger: other railways	-	-	-	6.6	6.6	n.a.
- Total Passenger	-	-	-	55.0	55.0	n.a.
- Freight services	-	-	-	5.4	5.4	n.a.
Air traffic						
- Passenger: Scheduled flights	-	-	-	93.2	93.2	n.a.
- Passenger: Charter flights	-	-	-	17.7	17.7	n.a.
- Total Passenger	-	-	-	110.9	110.9	n.a.
- Freight services	-	-	-	n.e.	n.e.	n.a.
TOTAL						
- Road	223.1	218.2	4.9	374.7	363.4	11.3
- Rail	-	-	-	60.3	60.3	-
- Aviation	-	-	-	110.9	110.9	-

Table 4-18: Congestion costs 2005, in € million, 1998 prices

	Additional costs due to disturbed traffic or small delays			Additional costs due to congested traffic or heavy delays		
	Total	Time	Fuel	Total	Time	Fuel
Road Traffic						
- Individual passenger transport	187.3	182.0	5.3	556.3	540.8	15.4
- Public passenger transport	56.7	56.7	-	11.5	11.5	-
- Freight Transport	-	-	-	75.9	72.0	3.9
Rail Traffic						
- Passenger Federal Railways	-	-	-	62.8	62.8	n.a.
- Passenger: other railways	-	-	-	8.6	8.6	n.a.
- Total Passenger	-	-	-	71.4	71.4	n.a.
- Freight services	-	-	-	7.5	7.5	n.a.
Air traffic						
- Passenger: Scheduled flights	-	-	-	223.7	223.7	n.a.
- Passenger: Charter flights	-	-	-	56.3	56.3	n.a.
- Total Passenger	-	-	-	280.0	280.0	n.a.
- Freight services	-	-	-	n.e.	n.e.	n.a.
TOTAL						
- Road	244.0	238.7	5.3	643.7	624.4	19.3
- Rail	-	-	-	78.9	78.9	-
- Aviation	-	-	-	280.0	280.0	-

The following tables present the average costs of the different modes based on the figures in the three preceding tables.[34]

Table 4-19: Average congestion costs in road transport 1996, 1998 and 2005, in €/1 000 vkm, 1998 prices

	Total costs in € mill.			**Vehicle-km** in mill. vkm			**Average costs** €/1 000 vkm		
	1996	**1998**	**2005**	**1996**	**1998**	**2005**	**1996**	**1998**	**2005**
Car	504	550	744	45 890	47 554	50 712	11.0	11.6	14.7
LGV	11	16	36	2 872	3 077	3 810	4.0	5.2	9.5
HGV	14	21	40	2 260	2 433	2 530	6.1	8.6	15.7

Table 4-20: Average congestion costs in rail transport 1996, 1998 and 2005, in €/train-km, 1998 prices

	Total costs in € mill.			**Train-km** in mill. train-km			**Average costs** €/train-km		
	1996	**1998**	**2005**	**1996**	**1998**	**2005**	**1996**	**1998**	**2005**
Rail Passenger	55.0	58.2	71.4	130.2	131.8	135.4	0.42	0.44	0.53
Rail Freight	5.4	6.4	7.5	28.6	28.7	30.0	0.19	0.22	0.25

34 Air transport has been omitted because no reasonable functional unit is available.

Table 4-21: Average congestion costs in urban public transport 1996, 1998 and 2005, in €/vkm, 1998 prices

	Total costs in € mill.			**Vehicle-km** in mill. vkm			**Average costs** €/vkm		
	1996	**1998**	**2005**	**1996**	**1998**	**2005**	**1996**	**1998**	**2005**
Urban/Local bus	8.1	8.1	8.2	46.6	49.0	50.4	0.17	0.17	0.16
Tramway	20.9	20.7	23.6	41.0	43.0	47.2	0.51	0.48	0.50
Trolley bus	39.5	35.0	36.5	31.7	32.4	33.3	1.25	1.08	1.10

Road: With regard to the fact that for UNITE an update of the recent official road congestion cost study in Switzerland (ASTRA, 1998) has been carried out, the resulting figures show a plausible development of congestion hours on the Swiss road network since 1995 (base year of ASTRA (1998)). Due to - in comparison to Swiss values of time - lower overall UNITE values of time, resulting congestion costs are likewise slightly lower. Sensitivity calculations using Swiss values of time show an increase of congestion costs from 1996 to 2005 of about 50%. The most important increase of congestion hours occurs on motorways, major inter-urban roads as well as on access roads to cities and agglomerations.

Rail: Congestion costs rail (passenger) show a steady increase from € 55 mill. in 1996 to € 58 mill. in 1998 and a projected € 71 mill. in 2005. Congestion costs in rail transport have been calculated for the first time in Switzerland within the UNITE project. The most sensitive factor regarding the magnitude of rail congestion costs is the fixed benchmark from which a delayed train is regarded as delayed. A benchmark of five minutes was set according to the SBB internal benchmark for their own quality assessment. Since for the 2005 forecast the delay structure of 2000 has been used, congestion costs in rail transport increase proportional to the assumed growth in passenger numbers. Despite the improvement of infrastructure on major lines in Switzerland (the so-called Bahn 2000), some bottlenecks in the rail infrastructure network are still very sensitive. With increasing train numbers, the probability of delays at this bottlenecks (i.e. Heitersberg-Tunnel) and their propagation to the total network is increasing. Therefore, the estimation has to be considered as conservative. Database for congestion costs in rail freight transport is only provisional and the allocation of delay causes of international train services to national networks is controversially discussed between national railway companies. Therefore, the presented figures should be carefully interpreted.

Urban public transport: Again, congestion costs in urban public transport have been calculated for the first time in Switzerland. Due to the fact that only very few transport companies collect delay data systematically, a rough extrapolation based on passenger-km has been carried out to obtain overall Swiss results. The share of small delays due to the increase in travel time in peak hour traffic conditions is around 84%. The results are – like in rail transport – highly sensitive on the chosen benchmark, from which heavy delays are taken into account. Based on the available data, delays in the delay-class of 4-6 minutes (with an average of 5 minutes) and higher have been used to calculate congestion costs for heavy delays.

Aviation: Congestion costs in aviation sum up to € 130 million in 1998. For 2005, an increase to around € 280 million has been estimated. Methodologically our approach leads to a close linkage between increasing passenger numbers and delay costs. A sound prediction of passenger figures is therefore crucial. Within the next years a sharp increase in congestion costs of aviation is very likely due to increasing passenger numbers and stricter rules regarding operation times of the Zurich airport. Although this is a very popular scenario, it is currently not clear whether Zurich airport will maintain its status as an international hub. The number of transfer passengers make up for around 40% total passengers in Zurich and play therefore an important role. Again, congestion costs are highly sensitive in regard to the used benchmark of 15 minutes. This benchmark meets international common practice and is also applied by airport operators and airlines.

No data for delays in air freight transport was available, therefore congestion costs of air freight transport have not been calculated.

The following table shows a rough estimation of additional airline costs due to delays in 1997, 1998 and 1999 as well as a very rough forecast for 2005. The results are based on sensitive company data. Analysing issuable costs of a sample of delayed flights, an extrapolation to all flights has been carried out. However, the results are only provisional and give a rough impression on the magnitude of additional airline costs due to delays. It should be considered that mainly costs which lead directly to additional expenditures are accounted for.

Table 4-22: Additional airline costs due to delays 1997, 1998, 1999 and 2005, in € million, 1998 prices

	1997	1998	1999	2005
Zurich	13.3	15.1	29.7	29.2
Geneva	6.0	6.3	12.7	10.1
Basel	1.6	3.2	7.2	13.1
Total	**20.9**	**24.6**	**49.7**	**52.5**

Additional costs for airlines due to delays sum up to approximately 20% of total congestion costs. It has to be mentioned that not all additional airline costs are included, since the relevant costs for a larger aircraft fleet and higher staff numbers in order to handle delays in air transport have not been available for Switzerland.

4.4 Accident Costs

In the following tables the results of the detailed calculations of the social and the external accident costs are summarised.

The first table shows the total social accident costs, i.e. the sum of transport system internal and external accident costs for the three transport modes road, rail and aviation.

The social accident costs amount to more than € 7.8 billion in the year 1998 which corresponds to about 3.3% of the Swiss GDP. This value is substantially higher than figures given in existing studies for Switzerland: In Maibach et al. (1999) the total accident costs (road and rail only) are estimated at about € 4.15 billion for the year 1995 (1995 prices).

The deviations can be ascribed to differences in the risk costs, i.e. the willingness-to-pay values to reduce the risk of fatalities and injuries caused by traffic accidents. The figures chosen in the Swiss study amount to € 1.1 million per fatality and to about € 18 000 for injuries. Within UNITE, significantly higher figures have been assumed (€ 1.77 million and fractions therefrom for injuries, see text after table 4-23).

Table 4-23: Social costs of transport accidents 1996, 1998 and 2005, in € million, 1998 prices

1998	Material damage	Administra-tive costs	Medical treatment	Production losses	Risk Value	Total
Road	1 193.0	715.6	237.2	290.0	5 232.0	7 667.9
Rail	5.4	4.6	0.3	6.9	58.4	75.5
Aviation	26.0	8.8	0.2	6.9	53.8	95.6
Total	1 224.4	729.0	237.7	303.8	5 344.2	7 839.0
1996						
Road	1 253.8	731.8	223.0	284.1	4 896.0	7 388.7
Rail	4.8	4.4	0.3	6.7	55.6	71.9
Aviation	26.0	8.8	0.2	6.8	51.9	93.6
Total	1 284.6	744.9	223.5	297.6	5 003.5	7 554.2
2005						
Road	1 157.9	704.2	231.3	276.5	5 277.9	7 647.8
Rail	4.4	3.8	0.2	5.7	50.4	64.5
Aviation	26.0	8.9	0.2	7.2	58.3	100.6
Total	1 188.2	717.0	231.7	289.3	5 386.5	7 812.8

Nevertheless, the very high figure of € 7.8 billion is first of all caused by a high valuation of injuries (total risk value of injuries: € 4.18 bill.) that results from the values defined in the UNITE Valuation Conventions (see Nellthorp et al., 2001 and table 2-13 of this report) and "our translation" of these values:

– If - as proposed in Nellthorp et al. (2001) - 1% of the WTP value of € 1.77 mill. € is applied per case of "**light injuries**", a total risk value of € 1.55 bill. results for this category.

– The total risk for the category "**severe permanent injuries**" (injured persons that remain invalid after a traffic accident) amounts to € 856 mill. Per case it is € 0.57 mill. (32% of the WTP value).

– Whereas the interpretation of the two categories of injuries mentioned above causes little problems, the interpretation of the category "**severe temporary**" is less clear: Starting point for the valuation is the fraction of 9% of the WTP given in the Valuation Conventions. For the interpretation we started from the official definition of the Swiss Statistical Office BFS and define that a severe temporary injury implies a stay at the hospital of at least one day. The valuation is directly given by the percentage rate of 9% of the WTP value (i.e. € 159 300 per case). The total risk value for this category sums up to € 1.77 bill.

  The question is how "good" the value of € 159 300 is for the category "severe temporary. A pilot willingness-to-pay study carried out for Switzerland (Schwab N and Soguel N, 1995) comes up with the following cost figures for similar categories of injuries:

  - injuries with stay in hospital but without permanent damages: € 75 000 / case
  - injuries with stay in hospital and light permanent damages: € 200 000 / case

  Compared to these figures the value of € 159 300 seems to be rather high. If we start form the Swiss value of € 75 000 / case (in factor costs = € 69 640), the total risk value for the category "severe temporary" comes down to € 753 mill. Thus, the valuation assumption used for this category of injuries is very sensitive for the result.

By far the largest part of the social accident costs "remain" within the transport system. Table 4-24 shows the external part of the social accident costs. As discussed in section 3.4 on methodological issues the difference between internal and external is that large because the cost block "risk costs" is considered as transport system internal with the exception of uncovered transfer payments of the social security.

Table 4-24: Transport system external costs of transport accidents 1996, 1998 and 2005, in € million, 1998 prices

1998	Material damage	Administrative costs	Medical treatment	Production losses	Risk Value	Total
Road	0.0	177.8	172.7	290.0	284.8	925.4
Rail	0.0	0.7	0.1	6.9	0.7	8.4
Aviation	0.0	1.3	0.1	6.9	1.9	10.1
Total	0.0	179.9	172.9	303.8	287.5	944.0
1996						
Road	0.0	181.9	162.4	284.1	266.6	894.9
Rail	0.0	0.7	0.1	6.7	0.7	8.2
Aviation	0.0	1.3	0.1	6.8	1.8	10.0
Total	0.0	183.9	162.5	297.6	269.1	913.1
2005						
Road	0.0	175.0	168.4	276.5	287.3	907.3
Rail	0.0	0.6	0.1	5.7	0.6	7.0
Aviation	0.0	1.3	0.1	7.2	2.0	10.6
Total	0.0	177.0	168.5	289.3	290.0	924.8

Table 4-25 shows in more detail who is the bearer of the total social costs. It shows that the largest part is directly borne by the individual transport congestions. This high share is again explained by the assumption that the risk value is an internal cost block. The largest part of the transport system external accident costs of table 4-25 is borne by the public sector through uncovered payments of the social security.

Table 4-25: The main cost bearer of the total social accident cost 1998, in € million, 1998 prices

	Private User	Transport Sector	Public Sector	Third Parties	Total
Road	4 559.8	2 182.6	635.4	290.0	7 667.9
Rail	55.5	11.6	1.6	6.9	75.5
Aviation	40.6	44.9	3.2	6.9	95.6
Total	4 655.9	2 239.1	640.2	303.8	7 839.0

In section 3.4 it is explained why vehicle specific statements cannot be made for the external costs under the victims perspective chosen in UNITE because of the problem of arbitrary cost allocation. Therefore, the vehicle specific figures given in table 4-26 refer to the total social accident costs.

Table 4-26: Social accident costs 1998 - detailed results per mode, in € million, 1998 prices

	Material damage	Administra-tive costs	Medical treatment	Production losses	Risk Value	Total
Road	**1 169.3**	**708.1**	**236.3**	**289.4**	**5 215.5**	**7 618.7**
Pedestrian, cycle	8.3	62.0	65.5	64.0	1 550.4	1 750.3
Motorcyle[1)]	108.4	92.0	61.1	68.6	1 213.0	1 543.0
Car	879.6	481.5	98.5	142.0	2 221.9	3 823.5
Coach	24.9	8.9	2.0	2.2	44.2	82.3
Light goods vehicle	66.0	30.2	5.1	6.0	93.4	200.7
Heavy goods vehicle	62.9	27.0	3.4	4.4	65.0	162.7
Others	19.1	6.5	0.6	2.3	27.7	56.1
Rail	**5.4**	**4.6**	**0.3**	**6.9**	**58.4**	**75.5**
Passenger train	4.4	2.4	0.1	1.9	15.3	24.1
Freight train	1.0	0.5	0.0	0.4	3.3	5.3
Others	0.0	1.6	0.2	4.5	39.7	46.1
Public Transport[2)]	**23.7**	**7.6**	**0.9**	**0.7**	**16.4**	**49.2**
Aviation	**26.0**	**8.8**	**0.2**	**6.9**	**53.8**	**95.6**
Below 2250 kg MTOW	9.6	3.5	0.1	3.1	23.2	39.4
2250-5700 kg MTOW	2.7	0.6	0.0	0.0	0.0	3.2
Over 5700 kg MTOW	7.5	1.9	0.0	1.0	8.8	19.2
Helicopter	5.8	2.1	0.1	1.6	12.7	22.2
Motorglider, glider	0.5	0.8	0.0	1.2	9.0	11.5
Total	**1 224.4**	**729.0**	**237.7**	**303.8**	**5 344.2**	**7 839.0**

1) Incl. mopeds

2) Public buses, tramways and trolley buses.

About 97% of the total social accident costs accrue in road transport. Table 4-26 shows that - as expected - high social costs are due to victims in the category unprotected road congestion (i.e. pedestrians and cyclists) and in the "dangerous" category motorcycle. In absolute figures, the social costs in the passengers car category dominate.

For road transport it is possible to present the results for the different types of road infrastructure, i.e. motorways and roads outside (inter-urban/rural roads) and inside built up areas (urban/local roads).

The figures confirm the well known fact that motorways are much safer compared to other road types: Though the motorways account for about 30% of the total road traffic performance, only less than 4% of the total social accident costs are caused by motorway accidents. The results for urban/local roads are in contrast to those for motorways: 67% of the costs are related to accidents on this road type which accounts for only 32% of the total mileage.

Table 4-27: Social accident costs of road transport 1998 - detailed results per road type, in € million

	Material damage	Administra-tive costs	Medical treatment	Production losses	Risk Value	Total
Pedestrian, cycle	**8.3**	**62.0**	**65.5**	**64.0**	**1 550.4**	**1 750.3**
Motorways	0.0	0.1	0.0	0.1	1.5	1.7
Trunk roads	1.0	8.5	9.3	8.5	202.8	230.1
Urban roads	7.3	53.5	56.2	55.4	1 346.1	1 518.5
Motorcyle[1)]	**108.4**	**92.0**	**61.1**	**68.6**	**1 213.0**	**1 543.0**
Motorways	0.4	0.3	0.2	0.2	4.4	5.5
Trunk roads	22.2	18.8	12.5	14.0	248.2	315.7
Urban roads	85.8	72.8	48.4	54.3	960.4	1 221.8
Car	**879.6**	**481.5**	**98.5**	**142.0**	**2 221.9**	**3 823.5**
Motorways	61.5	33.7	6.9	9.9	155.4	267.5
Trunk roads	350.1	191.6	39.2	56.5	884.3	1 521.8
Urban roads	468.0	256.2	52.4	75.5	1 182.1	2 034.3
Coach	**24.9**	**8.9**	**2.0**	**2.2**	**44.2**	**82.3**
Motorways	0.7	0.2	0.1	0.1	1.2	2.2
Trunk roads	10.5	3.7	0.9	0.9	18.5	34.5
Urban roads	13.8	4.9	1.1	1.2	24.5	45.5
Light goods vehicle	**66.0**	**30.2**	**5.1**	**6.0**	**93.4**	**200.7**
Motorways	3.9	1.8	0.3	0.4	5.5	11.9
Trunk roads	26.8	12.3	2.1	2.4	37.9	81.5
Urban roads	35.3	16.1	2.7	3.2	49.9	107.4
Heavy goods vehicle	**62.9**	**27.0**	**3.4**	**4.4**	**65.0**	**162.7**
Motorways	3.7	1.6	0.2	0.3	3.9	9.7
Trunk roads	25.6	11.0	1.4	1.8	26.4	66.1
Urban roads	33.6	14.4	1.8	2.3	34.8	87.0
Others	**19.1**	**6.5**	**0.6**	**2.3**	**27.7**	**56.1**
Total Road Transport	**1 169.3**	**708.1**	**236.3**	**289.4**	**5 215.5**	**7 618.7**
Public Transport[2)]	**23.7**	**7.6**	**0.9**	**0.7**	**16.4**	**49.2**
Motorways	0.0	0.0	0.0	0.0	0.0	0.0
Trunk roads	10.2	3.3	0.4	0.3	7.1	21.2
Urban roads	13.5	4.3	0.5	0.4	9.4	28.0

1) Incl. mopeds

2) Public buses, tramways and trolley buses.

From the figures presented above cost rates per unit of performance can be derived. With the victims perspective of UNITE ("monitoring") only the rate for the social accident costs can be calculated unless arbitrary cost allocation is accepted (see the discussion in section 3.4). The social accident cost rates using the UNITE perspective are given in table 4-28. The table also contains the results for the backcast and forecast years 1996 and 2005. We renounce presenting the results of these two years with the same level of detail like the UNITE base year 1998.

Table 4-28: Average social costs per unit of performance 1996, 1998 and 2005, in € million, 1998 prices

	Total social costs in mill. €			Social costs per vkm/train-km in €		
	1996	1998	2005	1996	1998	2005
Road	**7 339.3**	**7 618.7**	**7 600.3**			
Pedestrian, cycle	1 643.9	1 750.3	1 732.2	0.518	0.551	0.527
Motorcyle[1)]	1 458.9	1 543.0	1 338.0	0.835	0.862	0.719
Car	3 739.3	3 823.5	3 996.9	0.081	0.080	0.079
Coach	80.6	82.3	106.4	0.732	0.722	0.734
Light goods vehicle	198.1	200.7	210.9	0.069	0.065	0.055
Heavy goods vehicle	162.3	162.7	161.9	0.718	0.067	0.064
Others	56.2	56.1	54.1			
Rail	**71.9**	**75.5**	**64.5**			
Passenger train	23.0	24.1	19.7	0.177	0.183	0.146
Freight train	5.0	5.3	4.4	0.175	0.183	0.146
Others	43.8	46.1	40.4			
Public Transport[2)]	**49.3**	**49.2**	**47.5**	**0.185**	**0.181**	**0.168**
Aviation	**93.6**	**95.6**	**100.6**			
Below 2250 kg MTOW	38.6	39.4	41.6			
2250-5700 kg MTOW	3.2	3.2	3.2			
Over 5700 kg MTOW	18.9	19.2	20.0			
Helicopter	21.7	22.2	23.4			
Motorglider, glider	11.2	11.5	12.4			
Total social acc. costs	**7 554.2**	**7 839.0**	**7 812.8**			

1) Incl. mopeds
2) Public buses, tramways and trolley buses.

The figures for the total social accident costs show an increase between 1996 but almost stable situation between 1998 and 2005. Or to say it in other words: This very high cost block of the total transport costs in Switzerland will not decrease significantly despite numerous traffic safety measures taken and planned for the future.

In the case of the year 2005, the reduction in the accident rates (see section 4.4) overcompensates the cost increase assumed for valuation of damages, fatalities etc. on the one hand and the increase of traffic volume on the other hand. While this is true for the overall social accident costs, there are differences between the modes and especially between the vehicle categories:

– In the case of aviation, there is no cost decrease. The reason is that we used the same eleven-year-average for the accident rates for all three UNITE years. The differences in the total social costs only reveal the increase in the cost figures used for valuation.
– Those road vehicle categories with strong increases in traffic volume also show an increase in total social accident costs (e.g. car, coach, LGV). Nevertheless, also for these

categories a decrease of the average social accident costs (in €/vkm) can be expected because of the reduction in the accident rates.

So far, all the results refer to the victims perspective of UNITE ("monitoring"). For illustration purposes we also show the results if the causer or perpetrator perspective is taken. With this perspective also the rate for the average external accident costs can be calculated without arbitrary cost allocation. The following table shows the results.

Table 4-29: Average social and external accident costs per unit of performance 1998, perpetrator perspective, in € million, 1998 prices

	Social accident costs		**External accident costs**	
	Total in million €	**per vkm / train-km in €**	**Total in million €**	**per vkm / train-km in €**
Road	**7 685.4**		**953.1**	
Pedestrian, cycle	1 380.4	0.475	201.5	0.074
Motorcyle[1)]	1 320.9	0.700	221.8	0.105
Car	4 265.7	0.093	456.5	0.006
Coach	89.4	0.843	5.4	0.002
Light goods vehicle	279.8	0.082	31.3	0.023
Heavy goods vehicle	271.9	0.114	30.2	0.002
Others	77.3		6.4	
Rail	**75.5**		**8.4**	
Passenger train	55.6	0.422	5.8	0.000
Freight train	12.1	0.422	1.3	0.000
Others	7.8		1.3	
Public Transport[2)]	**59.5**	**0.301**	**2.6**	**0.001**
Aviation	**95.6**		**10.1**	
Below 2250 kg MTOW	39.4		4.4	
2250-5700 kg MTOW	3.2		0.0	
Over 5700 kg MTOW	19.3		1.1	
Helicopter	22.2		2.4	
Motorglider, glider	11.4		2.1	
Total	**7 916.0**		**974.2**	

1) Incl. mopeds
2) Public buses, tramways and trolley buses.

4.5 Environmental costs

4.5.1 Air Pollution

The total costs of air pollution of the four relevant transport modes are summarised in table 4-30. The total costs amount to approx. € 580 million in the UNITE base year 1998. About 93% of the costs are caused by the adverse effects of air pollutants to human health. The costs of material damages only amount to a bit more than € 11 million, those for damages on vegetation (e.g. crop losses) to about € 29 million.

The total costs are almost exclusively caused by road transport (96%). This share might tend to be an overestimation because of the following reasons:

- The PM10 emissions of rail transport are not taken into account though first tentative studies in Switzerland suggest that they may be substantial (see section 2.6.1). Therefore, the value given in the table should be considered as lower bound of costs.
- In the case of aviation only the air pollutants emitted during the LTO cycle (landing and take-off cycle) and the exhalation from fuelling on the three major Swiss airports have been included in the calculations. Furthermore, it should be noted that data about particle emissions have not been available for the calculations (see table 2-18). Like for rail transport, the costs given in the table below underestimate the "true costs" of air pollution caused by aviation. For Germany, where particle emissions are available, the damages caused by these emissions amount to about 30% of the total costs of air pollution. If this figure is transferred to Switzerland, the costs of air pollution of aviation increase to about € 25 million (year 1998).

Table 4-30: Costs of air pollution from transport 1996, 1998 and 2005, in € million, 1998 prices

Mode, transport category	1996	1998	2005
Road	**625.8**	**559.7**	**406.4**
Passenger Transport	377.5	332.4	228.5
Freight Transport	248.3	227.3	177.9
Rail	**3.6**	**4.5**	**5.2**
Passenger Transport	2.1	2.8	3.0
Freight Transport	1.5	1.7	2.2
Public transport	**31.8**	**28.5**	**20.8**
Diesel buses[1)]	31.5	28.2	20.5
Tramways	0.2	0.2	0.2
Trolley buses	0.1	0.1	0.1
Aviation	**15.6**	**17.3**	**23.9**
National Airports (ZH, BS and GE)	15.6	17.3	23.9
Total costs of air pollution	**645.3**	**581.8**	**435.8**

1) The costs for diesel buses (category PT) are also contained in the total of road transport. They are derived from this total based on information about the share of the category buses on the emissions of the different air pollutants.

In the case of road transport, the higher share of vehicles with cleaner technologies results in lower emissions and costs of air pollution respectively though traffic volume on road will significantly increase until 2005 (see table 2-2). This overcompensation of the volume effect by the technology effect can only be observed for road transport (incl. urban diesel buses). For aviation, a substantial increase of almost 40% is calculated. Rail remains an unimportant mode with regard to air pollution.

The total costs for road transport are substantially lower than the figures given in other publications dealing with the external costs of air pollution. The differences refer to all cost blocks of the total costs of air pollution but are especially relevant in the case of human health costs because this cost block is decisive for the total costs:

– In a study prepared by a tri-lateral research team from Austria, France and Switzerland for a WHO Ministerial Conference (see Bureau for Transport Studies (ed.), 1999) the health costs are assessed at € 2.2 billion for the year 1996 (range: € 1.1 to 3.4 billion). This study bases on a willingness-to-pay approach using a figure of € 0.9 mill. per fatality.
– In a project of within a National Research Programme (Maibach et al., 1999) a value of € 1.05 billion is assessed. The lower figure compared to the WHO study can be partly explained with the higher valuation of morbidity applied in WHO study. The figure of € 1 050 mill. bases on a comprehensive study for valuing the costs of air pollution (Ecoplan, 1996).
– In INFRAS/IWW (2000) a figure of € 2.86 billion is given.

The very large difference between these results and the figures given in 4-29 can be put down to two main reasons:

– The calculations of PM10 emissions carried out in Switzerland in the recent past resulted in much lower figures (i.e. a reduction by about 50%!) compared to older estimates. The UNITE calculations base on these new emission data, the other studies on the older data set. Recently launched projects will bring up new consolidated results about PM10 emissions of road and rail transport in Switzerland.
– There is a substantial difference 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 in the WHO-Study. The difference amounts to more than a factor of 3. This factor reveals considerable differences in the opinions of scientists with regard to the treatment of long-term mortality. While it is undisputed that long-term - and not short-term - mortality is the most relevant perspective and can only be estimated with long-term cohort studies observing the impact of air pollutants on the health of a number of persons, the differences refer to the application of the results from these studies: Whereas some scientists adjust these results because of higher air pollutant concentrations in the past, others restrain from doing so. Thus, the discrepancy reveals the considerable uncertainty still connected with the valuation of adverse environmental impacts and damages to human health and it also shows the necessity to take further efforts to exchange and discuss these issues among scientific specialists.

Against this background we don't see ourselves competent to judge whether the low value resulting from the application of the ExternE model and given in table 4-30 or the significantly higher results presented in three other studies for Switzerland come closer to the "real costs" of air pollution in Switzerland. We suggest to interpret the different figures as what they are: Results of calculations with different methodological approaches and especially with different assumptions taken.

Similar differences can also be found for the cost block "material damages": Here, a national in-depth study (INFRAS, 1992) and updates of this study (e.g. Maibach et al., 1999) assessed a value for the costs due to damages on buildings of more than € 200 million (year 1995), compared to the € 10 million calculated by the ExternE model. This time, the deviations are caused by differences in the methodological approach (dose-response functions in the ExternE model, observed changes in renovation and cleaning cycles in the Swiss study).

Starting from the figures for the total costs of air pollution of road transport in table 4-30, the shares of the vehicle categories on the total emissions (see sections 2.6.1 and 3.5.1) and the relative harmfulness of the different air pollutants, the average costs per vehicle kilometre can be estimated.

Table 4-31: Average costs of air pollution for road transport 1996, 1998 and 2005, in € / vkm, 1998 prices

Mode	**1996**	**1998**	**2005**
Motorcycles, bikes	0.004	0.005	0.005
Cars	0.008	0.006	0.004
Coaches	0.089	0.081	0.063
Buses	0.124	0.144	0.088
Light goods vehicles	0.014	0.012	0.007
Heavy goods vehicles	0.087	0.074	0.059

The figures show the high costs per vehicle kilometres for public buses many of them travelling in urban areas. The high cost rate is caused by high emission factors (in g/vkm) that result first of all from the frequent stop and go of public buses.

Looking at total costs of only € 4.5 million and the annual performance of about 160 million train-kilometre, the average costs of air pollution for rail transport amount to about € 0.03 / train-km.

4.5.2 Global Warming

Table 4-32 contains the estimates made for the costs of the CO_2 emissions of transport in Switzerland.

Table 4-32: Costs of CO_2 emissions from transport 1996, 1998 and 2005, in € million, 1998 prices

Mode, transport category	1996	1998	2005
Road	**291.8**	**307.7**	**352.6**
Passenger Transport	232.6	242.9	270.3
Freight Transport	59.2	64.9	82.3
Rail	**0.21**	**0.08**	**0.15**
Passenger Transport	0.12	0.05	0.08
Freight Transport	0.09	0.03	0.06
Public transport	**4.5**	**5.7**	**5.2**
Diesel buses[1)]	4.5	5.7	5.1
Tramways	0.02	0.02	0.02
Trolley buses	0.01	0.01	0.01
Aviation	30.9	**34.2**	49.1
National Airports (ZH, BS and GE)	10.1	11.1	15.1
Flights (Transit over Switzerland)	20.8	23.0	34.0
Total costs CO_2 emissions	**323.0**	**342.0**	**401.9**

1) The costs for diesel buses (category PT) are also contained in the total of road transport. They are derived from this total based on information about the share of the category buses on the total CO_2 emissions of road transport.

The general picture of the results is very similar to the one of the costs of air pollution. By far the largest share of the costs is contributed by the road transport sector (90%). The share of aviation is higher than in the case of the costs of air pollution because the emissions of CO_2 of aircrafts transiting Switzerland have been taken into account too ("flights" in table 4-32).

It should be remembered that European average avoidance costs of € 20 / tonne of CO_2 have been used to derive the values in the table above. It the Swiss transport sector specific value of € 80 / tonne of CO_2 were applied, the total cost would increase to € 1.37 billion (1998).

Unlike in the case of air pollution, the costs of CO_2 emissions will increase for all transport modes from 1998 to 2005. The improvement of fuel efficiency is not large enough to compensate the strong growth in traffic volumes.

Using the figures about fuel consumption of the different vehicle categories the average costs of CO_2 emissions for road transport can be derived.

As in the case of air pollution and because of the same reasons, the buses cause by far the highest costs per vkm. However, the difference between buses and cars, for example, is much less marked.
The average costs of rail transport per train-kilometre are negligibly small.

Table 4-33: Average costs of global warming for road transport 1996, 1998 and 2005, in € / vkm, 1998 prices

Mode	1996	1998	2005
Motorcycles, bikes	0.002	0.002	0.002
Cars	0.005	0.005	0.005
Coaches	0.018	0.018	0.020
Buses	0.023	0.029	0.025
Light goods vehicles	0.007	0.007	0.007
Heavy goods vehicles	0.018	0.018	0.022

4.5.3 Noise

In the table below the noise costs as estimated with the ExternE methodology are summarised for **road transport**.

Table 4-34: Noise costs of road transport 1996/98 and 2005, in € million, 1998 prices

Impact category	**1996/1998**	**2005**
Ischaemic heart disease	15.2	13.6
Hypertension	0.01	0.0
Subjective sleep quality (COI)	39.8	35.6
Loss of amenity (Hedonic Pricing)	476.8	426.4
Total	**531.8**	**475.6**

The figures show that the Hedonic Pricing approach generates by far the highest cost estimates. Obviously, road transport noise is first of all a problem of annoyance - reflected in reduced values / rents for flats as measured with the Hedonic Pricing approach - and not of adverse health impacts.

Because comparable input data are used, the costs lie in a very similar range as contained in available estimates in Switzerland:

– Estimate made within a National Research Programme, year 1995 (Maibach et al., 1999): approx. € 600 mill.
– "Official" figure, year 1993 (see INFRAS, 1995): approx. € 550 mill.

In a tentative way one can make a guess of an allocation of these costs to the different vehicle categories. For the estimates shown in table 4-35 the annual mileages of the different vehicle categories (see chapter 2) have been used whereby the mileages of heavy vehicles and motorcycles are weighted with a factor 10 compared to cars and light goods vehicles to take into account the much higher noise emissions of these vehicle categories per kilometre driven.

The noise costs of the buses are first of all caused by urban buses because noise costs are especially high in an urban context. Based on analysis for the urban area of Bern we guess that € 9 million are caused by this public transport category.

Table 4-35: Noise costs of road transport by vehicle category 1996/98 and 2005, in € million, 1998 prices

	Total noise costs in mill. €	
Vehicle category	**1996/1998**	**2005**
Motorcycles	99.2	86.82
Passenger cars	263.5	236.72
Buses	10.9	9.43
Coaches	6.3	6.72
Total Passengers Transport	**379.9**	**339.7**
Light goods vehicles	17.1	17.78
Heavy goods vehicles	134.8	118.10
Total Freight Transport	**151.9**	**135.9**

Using the same mileage figures to derive average cost figures, the following values result 1998 prices):

– Heavy vehicles, motorcycle: € 0.055 / vkm (1996/98), € 0.047 / vkm (2005),
– Light vehicles: € 0.006 / vkm (1996(98), € 0.005 / vkm (2005).

The figures for rail transport and aviation are summarised in table 4-36.

Table 4-36: Noise costs of rail transport and aviation 1996/98 and 2005, in € million, 1998 prices

	Rail transport		Aviation	
Impact category	**1996/1998**	**2005**	**1998**	**2005**
Costs of treatment of diseases	7.1	3.8	0.4	n.a.
Costs of sleep disturbance	19.2	10.4	2.9	n.a.
Loss of amenity (Hedonic Pricing)	33.4	18.0	23.2	n.a.
Total	**59.6**	**32.2**	**26.5**	**n.a.**

Compared to existing studies in Switzerland (€ 90 - 100 million) the estimate for rail transport is rather low. The largest part can be explained by the bonus of 5 dB(A) that is assumed to take into account the lower level of annoyance of railway noise compared to road transport noise (see section 3.5.3).

Because of the large efforts in Switzerland to reduce annoyance caused by railway noise, a significant decrease in the noise costs can be expected for the year 2005. The total noise costs are estimated to decrease by about 45%.

Using the annual train-kilometres performed by the Swiss railways, the following rough estimates of average noise costs can be derived (1998 prices):

– Base year 1998 (incl. '96): € 0.37 / train-km,
– Forecast year 2005: € 0.19 / train-km.

The noise costs of aviation calculated by the ExternE model of € 26.5 million for the three airports seem to be low though there are no in-depth estimates available for Switzerland for comparison. Nevertheless, a comparison with calculations made for the Dutch airport Schiphol gives evidence that the estimates for Switzerland should rather be interpreted as low value: Morrel and Lu (2000) finds in their analysis that the noise tax per landing should amount to about € 625 – and not to € 160 as in the late nineties -, if the tax level were to reflect the noise costs. If the Swiss figures is divided by the number of aircraft movements (see table 2-5) only a value of about € 60 results.

4.5.4 Nature, Landscape and Further Environmental Effects

In the following sections all results are described by type and mode of transport. Due to a new methodological approach for the Swiss pilot accounts, a comparison with former outputs and cost calculations cannot be drawn.

The total costs for nature, landscape and further environmental effects are shown for the three damage categories i) habitat loss and biodiversity, ii) unsealing costs for sealed ground and iii) cost for soil decontamination along transport infrastructure (for details see section on the methodology and Bickel et al. 2000).

a) Road Transport

As can be seen in the following table, about half of the road-based costs occur as costs for unsealing the motorways. In the 1950 base year no motorways were built so far. About 20% of the costs take into account the inter-urban and rural roads, of which again the largest part covers the unsealing costs. Costs of habitat losses (barrier effect, etc.) are only taken into account for the larger motorways and not for the smaller inter-urban and rural roads. They largely depend on the network in the accounting year and the annuity factor since the reference year 1950. Neither the tunnels nor the urban and local roads are considered for nature, landscape and further environmental effects. The following tables show the total costs for the accounting years 1998, 1996 and 2005.

Table 4-37: Total costs of road transport 1996, 1998 and 2005 estimated for nature, landscape and further environmental effects, in € million, 1998 prices

	Total costs of nature, landscape and further environmental effects (mill. €)											
	1996				1998				2005			
Mode of Transport	Habitat loss	Unsea-ling	Soil decont.	Total	Habitat loss	Unsea-ling	Soil decont.	Total	Habitat loss	Unsea-ling	Soil decont.	Total
Road												
Motorways <20m	5.8	19.5	1.9	27.2	5.7	22.2	2.1	30.0	5.8	19.7	1.9	27.5
Motorways >20m	1.7	1.8	0.6	4.1	1.9	2.3	0.7	4.9	1.9	1.9	0.6	4.4
Inter-urb./Rural roads >9m	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Inter-urb./Rural roads <9m	0.0	6.7	2.3	9.0	0.0	7.5	2.6	10.1	0.0	5.5	1.9	7.4
Total	**7.5**	**28.0**	**4.8**	**40.3**	**7.6**	**32.0**	**5.5**	**45.1**	**7.7**	**27.1**	**4.4**	**39.2**

The unsealing and soil decontamination costs are slightly decreasing until the year 2005. This is due the methodology used (see that chapter). For the calculation the total costs – for unsealing and decontaminating all the road infrastructure (existing at a certain year) – are subdivided by the respective number of years since the reference year (1950) without applying a discount rate on past costs[35]. Thus the overall costs for unsealing the roads and cleaning the soils are divided by more years in the year 2005 and are therefore smaller in a year's period.

The split between passenger and freight traffic is based on the mileage per type of vehicles (mopeds are not considered) and per type of network (i.e. motorways and inter-urban/rural roads). The mileage is weighed with the unit factor described in INFRAS/IWW (2000; i.e. the passenger car unit =1)[36]. The costs per weighted vehicle kilometres are given for the years 1996, 1998, and 2005 in the tables below.

Table 4-38: Total costs 1996, 1998 and 2005 estimated for nature, landscape and further environmental effects for passenger and freight transport, in € million, 1998 prices

	Total costs of nature, landscape and further environmental effects (mill. €)											
	1996				1998				2005			
Mode of Transport	Habitat loss	Unsea-ling	Soil decont.	Total	Habitat loss	Unsea-ling	Soil decont.	Total	Habitat loss	Unsea-ling	Soil decont.	Total
Road												
Passenger: Motorways	5.6	16.0	1.8	23.5	5.6	18.2	2.1	26.0	5.8	16.2	1.9	23.8
Passenger: Inter-urb./Rural	0.0	5.4	1.9	7.3	0.0	6.1	2.2	8.3	0.0	4.4	1.5	6.0
Freight: Motorways	1.9	5.3	0.6	7.8	1.9	6.3	0.7	9.0	1.9	5.4	0.6	8.0
Freight: Inter-urb./Rural	0.0	1.3	0.4	1.7	0.0	1.4	0.5	1.8	0.0	1.0	0.4	1.4
Total	**7.5**	**28.0**	**4.8**	**40.3**	**7.6**	**32.0**	**5.5**	**45.1**	**7.7**	**27.1**	**4.4**	**39.2**

More than half of the costs are calculated for passenger transport on motorways. Freight transport by light and heavy goods vehicles on motorways have a share of only one fifth of the total costs for road infrastructure.

Average costs for nature, landscape and further environmental effects are shown in the table 4-39 below. There is no basis of comparison of these costs with other studies, since there exists no studies with a similar approach. Maibach et al. (1999) roughly estimated further environmental costs at 1995 to about 210–350 mill. CHF (= € 130–216 mill., at comparable 1998 prices, of which about half is allocated to passenger transport) and INFRAS/IWW (2000) assumes the total costs 1995 for nature and landscape to be € 315 mill. per year for passenger transport and € 74 mill. for freight transport. All these estimations are much higher than the approximately € 40 million /year calculated in these Swiss pilot accounts. Most of the differences can be explained with different estimations for the sealed area taken into consideration.

35 Because no average life span of repaired soil and therefore no amortisation costs can be assumed. See also the German pilot accounts (Link et al., 2001) for further explanations for this approach.

36 The PCU (passenger car unit) used are as follows:
For passenger transport: Motorcycle = 0.5, car = 1, bus and coach = 3;
For freight transport: LGV = 1.5, HGV = 3

Table 4-39: Average costs for nature, landscape and further environmental effects in road transport 1996, 1998 and 2006, in €/1 000 vkm, 1998 prices

Mode of Transport	Total costs (mill. €)			Vehicle kilometre (mill.vkm)			Average costs (€/1000 vkm)		
	1996	1998	2005	1996	1998	2005	1996	1998	2005
Road									
Motorcycle	0.3	0.4	0.3	1 358	1 435	1 552	0.25	0.27	0.21
Car	30.1	33.4	29.1	45 890	47 554	50 712	0.66	0.70	0.57
Bus	0.1	0.1	0.1	194	196	202	0.44	0.48	0.33
Coach	0.3	0.3	0.3	110	114	145	2.73	2.92	2.32
LGV	3.1	3.5	3.5	2 872	3 077	3 810	1.07	1.13	0.91
HGV	6.4	7.3	6.0	2 260	2 433	2 530	2.83	3.01	2.36
Total Passenger	30.8	34.3	29.8	47 552	49 299	52 610	0.65	0.69	0.57
Total Freight	9.5	10.8	9.4	5 132	5 511	6 339	1.85	1.96	1.49
Total road	**40.3**	**45.1**	**39.2**	**52 684**	**54 809**	**58 949**	**0.77**	**0.82**	**0.67**

b) Rail Transport

For the calculation of costs for nature, landscape and further environmental effects only two damage categories are taken into account for railways; the costs for unsealing the ground and the costs for cleaning the impaired soil. This is because Switzerland has no high speed tracks for which a 100% sealing factor would be assumed and the costs for habitat losses (incl. the migration barriers for larger animals) could be taken into account. For the conventional tracks a sealing factor of only 50% is assumed. Compared to approximately € 40 million/year for road infrastructure accounted to nature and landscape, the approximately € 3 million/year for rail infrastructure are rather small. The following 3 tables give an overview of the costs.

Table 4-40: Total costs of rail transport 1996, 1998 and 2005 estimated for nature, landscape and further environmental effects, in € million, 1998 prices

	Total costs of nature, landscape and further environmental effects (mill. €)											
	1996				1998				2005			
Mode of Transport	Habitat loss	Unsea-ling	Soil decont.	Total	Habitat loss	Unsea-ling	Soil decont.	Total	Habitat loss	Unsea-ling	Soil decont.	Total
Rail												
High speed network	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Conventional network	0.0	2.1	0.9	3.0	0.0	2.0	0.9	2.9	0.0	1.9	0.8	2.8
Total	**0.0**	**2.1**	**0.9**	**3.0**	**0.0**	**2.0**	**0.9**	**2.9**	**0.0**	**1.9**	**0.8**	**2.8**

The total costs are slightly diminishing over the years due to decreasing railway infrastructure facilities.

The split between passenger and freight transport is calculated according to BFS (2000) in regard to axle kilometres driven. Thereafter, 65.6% of the costs could be attributed to passenger transportation and only 34.4% to freight transportation (BFS 2000). For all the accounting years 1998, 1996 and 2005, the split of 1998 is used. The same cost allocation methodology is used in the German pilot accounts.

Table 4-41: Total costs 1996, 1998 and 2005 estimated for nature, landscape and further environmental effects for passenger and freight transport on railways, in € million, 1998 prices

	Total costs of nature, landscape and further environmental effects (mill. €)											
	1996				1998				2005			
Mode of Transport	Habitat loss	Unsealing	Soil decont.	Total	Habitat loss	Unsealing	Soil decont.	Total	Habitat loss	Unsealing	Soil decont.	Total
Rail												
Passenger transport	0.0	1.4	0.6	1.9	0.0	1.3	0.6	1.9	0.0	1.3	0.5	1.8
Freight transport	0.0	0.7	0.3	1.0	0.0	0.7	0.3	1.0	0.0	0.7	0.3	1.0
Total	**0.0**	**2.1**	**0.9**	**3.0**	**0.0**	**2.0**	**0.9**	**2.9**	**0.0**	**1.9**	**0.8**	**2.8**

With increasing train kilometres and slightly decreasing total costs in the period 1996 to 2005, average costs for nature, landscape and further environmental effects in rail transport decline likewise.

Table 4-42: Average costs for nature, landscape and further environmental effects in rail transport 1996, 1998 and 2005, in €/train-km, 1998 prices

Mode of Transport	**Total costs** (mill. €)			**Train kilometre** (mill. Train-km)			**Average costs** (€/train-km)		
	1996	1998	2005	1996	1998	2005	1996	1998	2005
Rail									
Passenger transport	1.9	1.9	1.8	130.2	131.8	135.4	0.015	0.014	0.013
Freight transport	1.0	1.0	1.0	28.6	28.7	30.0	0.036	0.035	0.032
Total rail	**3.0**	**2.9**	**2.8**	**158.8**	**160.5**	**165.3**	**0.019**	**0.018**	**0.017**

About two thirds of the total costs on rail infrastructure are calculated for passenger transportation, and one third for freight transports.

Similar to road transport, the costs for nature, landscape and further environmental effects of this study cannot be compared to those of other studies due to different approaches. Maibach et al. (1999) roughly estimated further environmental costs for rail transport at 1995 to about 117–177 mill. CHF (= € 72–110 mill., at comparable 1998 prices) and INRAS/IWW (2000) assumes the total costs 1995 for nature and landscape to be € 10 mill. per year for (two thirds of which for passenger transportation). Again these estimations are much higher than the approx. € 3 mill. calculated in these Swiss pilot accounts. Most of the differences can be explained with different estimations for the sealed area taken into consideration.

c) Aviation

There are only two nature and landscape damage categories considered for aviation, the unsealing costs of runways and other airport infrastructure and the costs for decontaminating impaired soil within a theoretical radius of 50 m of the aggregated sealed area for national airports and 25 m for regional airports and airstrips. The category habitat losses can be neglected in the total costs for the same reasons as for rail transportation.

Table 4-43: Total costs 1996, 1998 and 2005 estimated for nature, landscape and further environmental effects, in € million, 1998 prices

	Total costs of nature, landscape and further environmental effects (mill. €)											
	1996				1998				2005			
Mode of Transport	Habitat loss	Unsea-ling	Soil decont.	Total	Habitat loss	Unsea-ling	Soil decont.	Total	Habitat loss	Unsea-ling	Soil decont.	Total
Aviation												
International airports	0.0	2.4	0.7	3.1	0.0	2.4	0.7	3.1	0.0	2.5	0.1	2.6
Regional airports	0.0	1.4	0.1	1.4	0.0	1.4	0.1	1.4	0.0	1.2	0.1	1.3
Sealed airstrips	0.0	0.8	0.1	0.9	0.0	0.8	0.1	0.9	0.0	0.8	0.1	0.9
Total	**0.0**	**4.6**	**0.8**	**5.4**	**0.0**	**4.6**	**0.8**	**5.4**	**0.0**	**4.5**	**0.2**	**4.7**

While the total sealed and impaired area of airports is still increasing until 2005, there is a decrease of the unsealing and soil decontamination costs until the year 2005. This effect can be explained with the methodology used, similar to the same effect seen for the road transportation (see that chapter). For the calculation the total costs are subdivided by the respective number of years since the reference year (1950) without applying a discount rate on past costs[37]. Thus the overall costs for unsealing the roads and cleaning the soils are divided by more years in the year 2005 and are therefore smaller in a year's period.

The approximately € 5.4 million allocated to nature, landscape and further environmental effects for aviation are again smaller than rough estimations of other studies. INFRAS/IWW (2000) assumed the total aviation costs for 1995 to be about € 40 mill.. Most of the difference can be explained with different estimations for the sealed area taken into consideration.

4.5.5 Nuclear Risk

Due to the new approach for the calculation of the shadow price per kWh nuclear power consumption, a comparison with other data for nuclear risk cost estimations cannot be meaningful. The results for the costs of nuclear risks due to electricity consumption are given in the table below for the two modes considered (railways and urban public transport).

Table 4-44: Total costs estimated for the nuclear risks of different modes of transport 1996, 1998 and 2005, in million CHF and €, 1998 prices

Means of transport		Costs of nuclear risks [mill. CHF]			Costs of nuclear risks [mill. €]		
		1996	1998	2005	1996	1998	2005
Railways	SBB	10.78	4.04	7.08	6.65	2.49	4.37
	KTU	2.65	0.94	1.15	1.63	0.58	0.71
Urban public transport	Trolley buses	0.92	0.87	0.78	0.57	0.54	0.48
	Tramways	1.31	1.22	1.26	0.81	0.76	0.78
Total		15.65	7.07	10.28	9.66	4.36	6.35

The shadow price per kWh of nuclear power (it is € 0.015/$kWh_{nuclear,}$ compared to € 0.035/$kWh_{nuclear}$ given in INFRAS/IWW (2000) should still be considered as a rough Swiss-based estimation. All the assumptions on which the shadow price is based are given in Zweifel and Umbricht (2000), summarised in Bickel et al. (2000). Since there is a cost span reflecting the assumption boundaries[38] we do not think it is appropriate to multiply the

37 Because no average life span of repaired soil and therefore no amortisation costs can be assumed. See also the German pilot accounts for further explanations for this approach.

38 The assumption that boundaries of the cost span can be represented as the maximum damage potential

shadow price with a PPP/GDP adjustment factor for the years 1996 and 2005. Thus, we refer to the same shadow price for all the accounted years.

Further, it must be kept in mind that the underlined shadow factor is based on a Swiss-specific calculation, taking into account the Swiss nuclear power plant mix, the cost internalisation, the insurance- and country-specific liability premium presuming a market-price based insurance system, among other cost-relevant factors.

The most decisive cost factor except of the annual power consumption is the nuclear power share of the electricity mix. For the urban public transport systems the Swiss electricity production mix is assumed, whereof for the railway companies the SBB-specific production mix is considered (see tables 2-17, 3-26 and 3-29). The first has a nuclear power share of about 40% (1998), the latter has a much lower nuclear power share due to the significantly large hydro power production. For the railway companies, the amount of hydro power produced for each year is most sensitive to costs. In 1998, the nuclear share was almost 9.5% of which in 1999 there is zero percent nuclear power consumed due to the extensive hydro power production during this year. For the 2005 forecast, a nuclear power share of almost 15% (based on rough and uncertain estimations of the SBB) is taken into account. For the regional and smaller railway companies (KTU) the electricity consumption is gradually decreasing due to the higher efficiency caused for example with lighter vehicles.

The nuclear share and therefore the nuclear risk costs for 2005 are based on different assumptions for rail and urban public transport. The specific nuclear share for rail transportation varies much more within the years than the nuclear share for trolley buses and tramways (the first depends on the annually produced water power by the rail transport systems, the latter shows the Swiss power production mix). Besides that, the 2005 nuclear power share for rail transportation reflects an uncertain assumption, whereof for the urban public transport systems a best guess with the power mix of the year 1999 is taken into consideration. For these reasons the 2005 forecast for the different modes cannot be compared with one another.

The split of the cost category units is based on estimations given in BFS (2000) according to axle kilometres of the passenger and freight traffic. The following table gives an overview of the desegregated cost figures.

Table 4-45: Total costs for passenger and freight transport 1996, 1998 and 2005, in € million, 1998 prices

Means of transport		Costs of nuclear risks [mill. €]		
		1996	1998	2005
Railways	Passenger traffic	5.44	2.02	3.34
	Freight traffic	2.85	1.06	1.75
Urban public transport	Passenger traffic	1.37	1.29	1.26
	Freight traffic	0.00	0.00	0.00
Total		9.66	4.36	6.35

About two thirds of the total costs of the rail transport – and all the costs of urban public transport – can be allocated to passenger traffic according to the split based on axle kilometres given in BFS (2000).

estimated at 100 billion CHF, average cost internalisation estimated to be 2%, etc. The most sensitive parameter is the assumed maximum damage potential of a nuclear power plant accident.

4.6 Taxes, Charges and Subsidies[39]

4.6.1 Road

Table 4-46: Infrastructure road, revenues 1996, 1998 and 2005, in € million, 1998 prices

Vehicle categories	1996	1998	2005
Mopeds	10.47	9.31	7.81
Motorcycles	71.10	80.56	63.81
Cars	3 225.48	3 391.41	3 025.44
Coaches	25.67	26.57	15.73
Buses	9.97	8.74	3.41
LGV	309.82	338.68	267.03
Trucks	469.47	476.25	685.12
Trailer	49.05	50.03	74.33
Tractor for semi-trailer	74.48	82.77	96.29
Semi-trailer	16.07	17.88	23.90
Total	**4 261.58**	**4 482.19**	**4 262.87**

The 2005 revenues from mopeds, motorcycles, cars, coaches and buses have a tendency to decrease. These figures take the forecast mileage, the expected fuel consumption (declining slightly because of technical progress) and the change in the structure of the vehicle stock into account. Because the nominal tax rate remain mainly constant, a decline of the real tax rates occurs. But revenues from all vehicles for freight transportation are higher in 2005 than in 1998. This is due to the introduction of the distant levy on heavy lorries and the introduction of the new weight limit for lorries that has risen to 40 tonnes. The following figure shows different sources of the revenues. The arguments presented earlier hold for the following figures as well. The effect of the institutional changes for lorries shows in significantly higher revenues from the distance levy of heavy lorries. In all other categories, a decline of the revenues is to be expected.

The figures shown as revenues from VAT refer on the one hand to the VAT raised on the fuel tax part of the petrol and diesel prices, and on the other hand on the VAT on car taxes and the VAT on duty payments for imports of vehicle components.

39 Subsidies include all spendings of public authorities in connection with transport infrastructure or operation, especially the compensation payments for the owner of infrastructure (rail, inland waterways), the lost interest payments of credits from the public authorities at reduced interest rates (rail, air, inland waterways), the debt release (rail, air, inland waterways), etc.

Table 4-47: Infrastructure road, different sources of the revenues 1996, 1998 and 2005, in € million, 1998 prices

Different sources of revenues	1996	1998	2005
Fuel tax petrol	2 205	2 285	2 071
Fuel tax diesel	552	573	518
Car tax, Import tax	80	125	75
Vehicle tax	993	1 041	933
Annual highway charge	150	159	141
Heavy traffic tax (1)	104	107	358
VAT	177	192	166
Total	**4 262**	**4 482**	**4 263**
(1) 2005: Distance levy of heavy lorries			

4.6.2 Rail

a) Infrastructure revenues and subsidies

Table 4-48: Infrastructure rail, revenues and subsidies 1996, 1998 and 2005, in € million, 1998 prices

	1996	1998	2005
Revenues from infrastructure use charges	643	774	774
Other revenues	590	1 001	609
Subsidies	984	962	925
Total	**2 217**	**2 736**	**2 308**

In Switzerland, all important railway companies offer not only transport services but also own railway infrastructure. In the corresponding business accounts, infrastructure is separated from the transport services. Therefore, the transport division "freight transport" pays internal charges to the infrastructure division for the use of the infrastructure. These are not really monetary payments, they blow up the business account of the company and in a consolidated business account these internal charges are compensated; thus the consolidated business account gets shorter.

Table 4-49: Infrastructure rail, detailed revenues and subsidies 1996, 1998 and 2005, in € million, 1998 prices

	1996		1998		2005	
	Passenger transport	Freight transport	Passenger transport	Freight transport	Passenger transport	Freight transport
Revenues from infrastructure use charges	422	221	508	266	508	266
Other revenues	387	203	656	344	399	209
Subsidies	646	339	631	331	607	318
Total	**1 454**	**763**	**1 795**	**941**	**1 514**	**794**

In the table above, the figures are additionally divided into passenger and freight transport. The separation has been done using the indicator axle kilometre (BFS, 2000).

Looking at the development of the revenues, it stands out that there is a decline from 1998 to 2005. The reason for this is mainly a question of the definition of infrastructure used by the railway companies. Until 1998 the definition is widespread and takes into account for example all the railway stations (with restaurants, etc.). Since 2000, more and more railway companies make an effort to define a so-called core infrastructure, covering only parts that are really essential for processing rail passenger and freight transport. This development shows mainly in declining 'other revenues' (e.g. rent receipts), whereas the revenues from infrastructure use charges and the subsidies remain almost constant.

In Switzerland, public authorities pay different subsidies for infrastructure and for transport services, therefore specific subsidies are shown for infrastructure in the table above.

b) Supplier revenues and subsidies

Table 4-50: Supplier revenues and subsidies of rail transport 1996, 1998 and 2005, in € million, 1998 prices

	1996			1998			2005		
Cost category	**pass.**	**freight**	**Total**	**pass.**	**freight**	**Total**	**pass.**	**freight**	**Total**
Revenues	1 477	800	2 278	1 441	750	2 190	1 389	756	2 145
Subsidies	675	74	749	586	73	659	607	66	673

In passenger transport as revenues are constantly decreasing, less subsidies are being paid. Projections in freight transport are somewhat more optimistic with revenues slightly increasing until 2005 and subsidies are declining.

4.6.3 Road Based Public Transport

a) Supplier revenues and subsidies

The following table 4-51 presents in detail revenues and subsidies of urban and regional public transport. For 2005 only the total amount of subsidies could be estimated.

Between 1996 and 1998, total subsidies for public transport could be reduced by approx. € 100 million. The main reason for that decline is the introduction of a new railway law which enabled a more competitive market structure in rail transport as well as in public transport. As a consequence, transport companies had to improve their efficiency and productivity which contributed to a reduction of subsidisation.

A rough estimation concerning future revenues and subsidies in 2005 was carried out. The results of the forecast calculation show a slight increase in total revenues as well as a higher increase in subsidies. The reason for that has already been discussed in the supplier operating cost result section (see section 4.2).

Table 4-51: Supplier revenues and subsidies of road based urban transport 1996, 1998 and 2005, in € million, 1998 prices

	1996			1998			2005		
	RBS (regional buses)	**UPT** (tram, trolley, bus)	**Total**	**RBS** (regional buses)	**UPT** (tram, trolley, Bus)	**Total**	**RBS** (regional buses)	**UPT** (tram, trolley, bus)	**Total**
Total Transport Revenues without compensation, subsidies	**221**	**470**	**691**	**243**	**432**	**675**	**250**	**442**	**691**
Compensation payments Federal Government	98	19	116	140	19	159	n.e.	n.e.	n.e.
Compensation payments Cantons and others	28	39	66	56	104	160	n.e.	n.e.	n.e.
Compensation payments regional buses (Federal and cantonal government)	110	0	110	22	0	22	n.e.	n.e.	n.e.
Other operating subsidies	69	313	382	23	202	224	n.e.	n.e.	n.e.
Total Subsidies	**305**	**371**	**674**	**241**	**325**	**565**	**272**	**353**	**625**

4.6.4 Aviation

Table 4-52: National airports, revenues 1996, 1998 and 2005, in € million, 1998 prices

	1996	1998	2005
Airport taxes	248.29	284.31	383.76
Rents	171.74	183.34	246.99
User charges	68.82	73.23	98.99
Additional revenues	33.92	34.73	49.36
Commercial charges	30.54	37.03	47.48
Other services	19.02	23.25	32.50
Revenues assets	12.24	6.84	9.28
Extraordinary revenues	8.99	8.52	12.62
Total revenues	**593.56**	**651.24**	**880.99**

Table 4-53: Flight control, revenues 1996, 1998 and 2005, in € million, 1998 prices

	1996	1998	2005
Airport taxes	154.32	158.11	150.45
Rents	0.00	0.00	0.00
User charges	0.00	0.00	0.00
Additional revenues	0.00	0.00	0.00
Commercial charges	0.00	0.00	0.00
Other services	0.95	0.97	0.92
Revenues assets	0.00	0.00	0.00
Extraordinary revenues	0.00	0.00	0.00
Total revenues	**155.26**	**159.08**	**151.37**

The figures for revenues infrastructure aviation are divided into the table for the national airports and the flight control. The development of the revenues of the national airports points to significant growth in air traffic and the number of take-offs and landings. In contrast, the revenues of the flight control remain almost constant.

4.6.5 Inland Waterways

Table 4-54: Infrastructure inland waterways, revenues 1996, 1998 and 2005, in € million, 1998 prices

	1996	1998	2005
Revenues	11.74	13.11	15.05
Subsidies	0.03	0.03	0.00
Total	**11.77**	**13.14**	**15.05**

Because of enlargements of the Rhine ports, the capacity of the ports will increase, and with a significantly growing number of (container) ships to clear the revenues will rise noticeably.

5 Summary: Final Presentation of the Results per Mode

5.1 Swiss Road Account

Table 5-1: Swiss road account for 1996, 1998 and 2005, € million, 1998 prices

Costs **Core information**	**1996**	**1998**	**2005**
Infrastructure Costs	4 018	4 030	5 553
Fixed			
Variable			
Accident costs (external)[1)]	895	925	907
Environmental costs	1 403	1 354	1 200
Air pollution	594	532	386
Global warming	287	302	348
Noise	521	521	466
Total	**6 315**	**6 310**	**7 660**
Additional information			
Congestion costs[2)]	529	587	819
Time costs	513	568	795
Fuel costs	16	19	25
Accident costs (internal)	6 494	6 743	6 741
From this: risk value	4 896	5 232	5 278
Environmental costs	40	45	39
Nature and landscape, soil and water pollution[3)]	40	45	39
Nuclear risk[3)]			
Revenues			
Directly related to a specific cost category			
Charges for infrastructure usage	254	266	499
Fixed	254	266	141
Variable[4)]			358
Total	**254**	**266**	**499**
Other transport specific revenues			
Annual vehicle tax	993	1 041	933
Fuel tax	2 757	2 858	2 589
Car import tax	80	125	75
VAT[5)]	177	192	166
Total	**4 007**	**4 216**	**3 763**
Subsidies			

[1)] Transport system external costs only: Included are those cost parts that are not borne by road users and insurance companies of the transport sector but by the public sector and third parties (i.e. uncovered payments of the social security, administrative and medical treatment costs not covered by payments of the auto liability insurance, production losses). The transport system internal costs are given below under "Additional information". – [2)] Total delay costs due to disturbed and congested traffic. – [3)] Because there is no standardised methodology for the calculation of these costs, the figures given here are approximate indications. – [4)] Introduction of the distance-dependent heavy vehicle fee in 2001. – [5)] Revenues from VAT refer on VAT raised on fuel tax part of petrol and diesel as well as the VAT on car taxes and duty payments for imports of vehicle components (revenues from VAT are officially regarded as revenues of the road account).
Source: Suter et al. (2002)

The total of the different cost categories given in the table above adds up to more than € 13.7 billion which corresponds to approx. 5.8% of the Swiss GDP.

The total social accident costs (sum of transport system internal and external costs) of more than € 7.6 billion are by far the highest cost block followed by the infrastructure costs. The total accident costs are dominated by the risk costs, i.e. the valuation of fatalities and injuries using a willingness-to-pay approach.

The largest part of the road transport costs are borne by actors within the road transport system. The infrastructure costs are more than covered with the directly and non-directly allocated revenues. However, the transport system external costs (external accident and environmental costs) still sum up to more than € 2.3 billion, or about 15% of the total costs.
The largest cost block of the external costs are the environmental costs of € 1.4 billion.

From the results for the year 2005 as presented in chapter 4, an increase of the total costs of road transport by more than 10% up to about € 15.3 billion (in 1998 prices) can be assessed. This increase is first of all caused by higher infrastructure costs (+38%) and congestion (user) costs (+40%). The overall lower environmental costs (1998: € 1.4 billion, 2005: € 1.24 billion) partly compensate these cost increases. The total social accident costs remain almost stable.

The following table 5-2 contains the average costs per vehicle-kilometres for selected vehicle categories of road transport. The cost rates have been derived by using the mileage given in table 2-2.

Table 5-2: Average cost rates for road transport in Switzerland 1998, in € / vkm

	1998				
	Motor-cycles[1)]	Passenger cars	Coaches and buses[2)]	LGV	HGV[3)]
Core information					
Infrastructure costs	0.051	0.064	0.275	0.085	0.229
Fixed	-	-	-	-	-
Variable	-	-	-	-	-
(External) accident costs[4)]	0.124	0.015	0.072	0.013	0.014
Environmental costs	0.062	0.017	0.201	0.025	0.148
Air pollution	0.005	0.006	0.121	0.012	0.074
Global warming	0.002	0.005	0.025	0.007	0.018
Noise	0.055	0.006	0.055	0.006	0.055
Total I	**0.237**	**0.096**	**0.548**	**0.123**	**0.391**
Additional information					
Delay costs	-	0.012	-	0.005	0.009
Internal accident costs	0.738	0.065	0.352	0.052	0.053
Material damages	0.061	0.018	0.157	0.021	0.026
Risk value	0.678	0.047	0.196	0.030	0.027
Environmental costs	-	-	-	-	-
Nature, landscape, soil and water pollution	0.000	0.001	0.001	0.001	0.003
Total II	**0.738**	**0.077**	**0.354**	**0.058**	**0.064**
Revenues					
Fixed	-	-	-	-	0.044
Car tax, import tax	-	-	-	-	-
Vehicle tax	-	-	-	-	-
Vignette	-	-	-	-	-
Heavy traffic tax	-	-	-	-	0.044
Variable	-	-	-	-	-
Fuel tax	-	-	-	-	-
Distance related infrastructure charges	-	-	-	-	-
VAT5[)]	-	-	-	-	-
Total	**0.050**	**0.071**	**0.114**	**0.110**	**0.258**
Basic data					
Vehicle-kilometres (mill. vkm)	1 790	47 554	310	3 077	2 433
Passenger-kilometres (mill. pkm)	2 121	77 195	2 242		
Tonne-kilometres (mill. tkm)				1 344	18 160

[1)] Includes mopeds. - [2)] Privat an public buses. - [3)] Only vehicles for goods transport. Agricultural vehicles and industrial vehicles are not included. - [4)] Includes external and internal accident costs. Because of the monitoring perspective of UNITE, the external accident costs cannot be allocated to the different vehicle categories unless arbitrary cost allocation is accepted. - [5)] VAT on fuel tax.

Source: Suter et al. (2002)

5.2 Swiss Rail Account

Table 5-3: Swiss rail account for 1996, 1998 and 2005, € million, 1998 prices

Costs **Core information**	**1996**	**1998**	**2005**
Infrastructure Costs	2 768	2 762	2 606
Fixed			
Variable			
Supplier operating costs	2 894	2 869	2 389
Out of these: Track & station charges [1)]	643	774	774
Accident costs (external)[2)]	8.2	8.4	7.0
Environmental costs	63.4	64.2	37.5
Air pollution[3)]	3.6	4.5	5.2
Global warming	0.2	0.1	0.1
Noise	59.6	59.6	32.2
Total	**5 091**	**4 930**	**4 266**
Additional information			
Congestion costs	60	65	79
Accident costs (internal)	64	67	58
From this: risk value	56	58	50
Environmental costs	11.3	6.0	7.9
Nature and landscape, soil and water pollution [4)]	3.0	2.9	2.8
Nuclear risk[4)]	8.3	3.1	5.1
Revenues			
Directly related to a specific cost category	643	774	774
Track charges	643	774	774
Fixed			
Variable			
Station charges			
User Tariffs[5)]	2 277	2 191	2 145
Total	**2 920**	**2 965**	**2 919**
Other transport specific revenues	0	0	0
Fuel tax			
Eco tax			
VAT			
Total	**0**	**0**	**0**
Subsidies[6)]	1 733	1 621	1 598
Non-transport related revenues of rail companies [7)]	590	1 001	609

[1)] The rail track charges are not taken into account to calculate the total of the costs (line before "Additional information") because they are "contained" in the infrastructure costs . – [2)] Transport system external costs only: Included are those cost parts that are not borne by rail users and insurance companies of the rail sector but by the public sector and third parties. The transport system internal costs are given below under "Additional information". – [3)] Emissions of particles not included.– [4)] Because there is no standardised methodology for the calculation of these costs, the figures given here are approximate indications. – [5)] Subsidies and VAT are excluded. – [6)] Subsidies include the provision of infrastructure, for debt relief, for the provision of rail services etc. – [7)] Not transport related revenues for the provision of infrastructure (stations, industrial areas and buildings etc.).

Source: Suter et al. (2002)

The total of the cost categories estimated for rail transport is significantly lower than for road transport: It amounts to approx. € 5.1 billion, or to about 38% of the figure assessed for road transport (without supplier operating costs: almost € 3 billion or about 21% of the costs of road transport). The largest cost blocks are the infrastructure and the supplier operating costs which are both in the same order of magnitude.

The share of the transport system external part is significantly higher than for road transport: Almost 33% of the costs - about € 1.7 billion in absolute terms - are first of all borne by the public sector through subsidies and by third parties. As expected, the subsidies are by far the largest part of the transport system external costs. In the case of the environmental costs, only the noise costs really matter.

For the future (i.e. the year 2005), a decrease of these costs by about 13% down to € 4.4 billion (in 1998 prices) can be expected. The lower total costs are mainly the result of a decrease of the supplier operating costs but also of the infrastructure costs. Lower costs are furthermore expected for the noise and the accident costs. Higher values can be found for the congestion (user) costs and for the - rather unimportant - costs of air pollution, global warming and nuclear risks.

The total amount of subsidies (non-transport related revenues of about € 1 billion (1998) excluded, see footnote [7)] above) is estimated to stay rather stable between 1998 and 2005 (approx. € 1.6 billion, in 1998 prices). The same holds for the tariff revenues.

From the figures in table 5-3 and table 2-3 and the results in chapter 4, one can estimate the average costs per train-kilometre as presented in table 5-4.

Table 5-4: Average cost rates for rail transport in Switzerland 1998, in € / train-km

	1998	
	Passenger	Freight
Core information		
Infrastructure costs	13.75	33.10
Fixed	-	-
Variable	-	-
Supplier operating costs	15.17	30.31
External accident costs	0.02	0.02
Administrative	0.00	0.00
Health costs	0.00	0.00
Production loss	0.01	0.01
Environmental costs	0.39	0.43
Air pollution	0.02	0.06
Global warming	0.00	0.00
Noise	0.37	0.37
Total I	**29.32**	**63.85**
Additional Information		
Delay costs	0.44	0.22
Internal accident costs	0.17	0.17
Administrative [1)]	0.02	0.02
Health costs [1)]	0.00	0.00
Material damages	0.03	0.03
Risk value	0.12	0.12
Environmental costs	0.01	0.03
Nature, landscape, soil and water pollution	0.01	0.03
Nuclear risk	0.02	0.04
Total II	**0.62**	**0.42**
Revenues		
User tariffs	10.93	26.13
Track charges	3.85	9.27
Non-transport-related revenues	4.98	11.99
VAT [2)]	-	-
Total (without track charges)	**15.91**	**38.12**
Subsidies	**9.23**	**14.08**
Infrastructure subsidies	4.79	11.53
Subsidies to operators for services	4.45	2.54
Basic data		
Train-kilometres (mill. train-km) [3)]	131.80	28.70
Passenger-kilometres (bill. pkm)	14.10	
Tonne-kilometres (bill. tkm)		9.26

[1)] The internal part of these costs, i.e. covered by payments of liability insurance companies. – [2)] VAT on fuel tax. However, diesel traction is not relevant in Switzerland. - [3)] Figures for 1997.

Source: Suter et al. (2002)

5.3 Swiss Road Based Public Transport Account

Table 5-5: Swiss account for road based PT for 1996, 1998 and 2005, € million, 1998 prices

Costs **Core information**	**1996**	**1998**	**2005**
Infrastructure Costs[1]			
Fixed			
Variable			
Services			
Supplier operating costs	1 436	1 270	1 316
Accident costs (external)[2]			
Environmental costs	47.2	45.1	35.1
Air pollution	31.8	28.5	20.5
Global warming	4.5	5.7	5.2
Noise	10.9	10.9	9.4
Total	**1 483.2**	**1 315.1**	**1 351.1**
Additional information			
Congestion costs	69	64	68
Accident costs (internal)[2]			
From this: risk value			
Environmental costs	1.4	1.3	1.3
Nature and landscape, soil and water pollution[3]			
Nuclear risk[3]	1.4	1.3	1.3
Revenues			
Directly related to a specific cost category			
Charges for infrastructure usage	0	0	0
Fixed			
Variable			
Subsidies for concessionary fares			
User Tariffs[4]	691	675	692
Other transport specific revenues	0	0	0
Fuel tax			
VAT			
Subsidies[5]	676	566	625
Non-transport related revenues of PT companies[6]			

[1] The infrastructure costs of urban and regional buses of € 57.5 mill. in 1998 are contained in the Swiss road account. The costs of special infrastructure for tramways and trolley buses are part of the supplier operating costs. - [2] Accident costs are included in road and rail transport accounts. Because of the problem of arbitrary cost allocation, only the figures for the total of transport system internal and external can be calculated for public transport: It amounts for buses, trolley buses and tramways to about € 49.2 million in 1998. - [3] Because there is no standardised methodology for the calculation of these costs, the figures are approximate indications. Nature, landscape and further environmental effects: Included in road and rail transport. - [4] Subsidies and VAT are excluded.- [5] Subsidies include the provision of infrastructure, for debt relief, for the provision of services etc. and are shown in monetary terms. - [6] No separation from 'other revenues' possible.

Source: Suter et al. (2002)

For public transport (excl. rail) it is not possible to draw a complete picture because some of its modes are also part of road transport. In order to avoid double counting, table 5-5 contains only cost and revenue figures which are not included in the Swiss road account (table 5-1).

As expected, the figures for a mode operating especially in urban areas show high congestion costs. Furthermore, the environmentally-friendly mode is supported substantially with public subsidies: For the regional and urban public transport services some € 566 million – or 35% of the subsidies for rail transport – are spent annually by the public. The consequence of these significant subsidies is that the share of the transport system external costs lie in the same order of magnitude as for rail transport.

There is only a limited change in total costs predicted for the future, namely a slight increase of about 3% from 1998 to 2005. Because this cost increase in absolute figures (about € 40 million) is assessed to be higher than the growth in revenues (some 2.4% in relative terms or € 17 million in absolute terms), an additional need for subsidies is forecasted for 2005 (approximately +10%).

As for the modes road and rail, the table 5-6 contains average costs for non-rail, i.e. road based public transport services in Switzerland. The mileages are taken from table 2-4.

Table 5-6: Average cost rates for road based PT in Switzerland 1998, in € / vkm

	1998		
	Regional Public Transport	Urban Public Transport	Total Non-Rail Public Transport
Core information			
Infrastructure Costs [1]		-	-
Fixed		-	-
Variable		-	-
Supplier operating costs	3.35	6.25	4.68
External accident costs [2]		-	-
Environmental costs	0.19	0.14	0.17
Air pollution [3]	0.14	0.14	0.14
Global warming [4]	0.03	0.03	0.03
Noise		0.07	0.04
Total I	**3.53**	**6.39**	**5.01**
Additional information			
Delay costs [5]	0.00	0.51	0.24
Internal accident costs [2]		-	-
Environmental costs	0.0007	0.02	0.02
Nature, landscape, soil and water pollution	0.0007		- 0.0007
Nuclear risk		- 0.02	0.02
Total II	**0.0007**	**0.53**	**0.2**
Revenues			
User tariffs	1.65	3.47	5.13
Subsidies	1.64	2.61	4.25
Basic data			
Vehicle-kilometres (mill. vkm)	147.00	124.40	271.40
Passenger-kilometres (bill. pkm)	1.60	3.09	4.69

[1] Infrastructure costs included in the road account. - [2] Accident costs included in road account. - [3] Only diesel buses. [4] Diesel buses and CO2-emissions from electricity production. [5] No delay information available for regional bus servic

Source: Suter et al. (2002)

5.4 Swiss Aviation Account

Table 5-7: Swiss aviation account for 1996, 1998 and 2005, € million, 1998 prices

Costs **Core information**	**1996**	**1998**	**2005**
Infrastructure Costs			
Fixed			
Variable			
Airports	607	650	899
Air traffic management services			
Flight control	151	154	147
Accident costs (external)[1]	10	10	11
Environmental costs	74	78	73
Air pollution[2]	16	17	24
Global warming[3]	31	34	49
Noise	27	27	n.a.
Total	**842**	**892**	**1 130**
Additional information			
Congestion costs	111	132	280
Accident costs (internal)	84	86	90
From this: risk value	52	54	58
Environmental costs	3.1	3.1	2.6
Nature and landscape, soil and water pollution[4]	3.1	3.1	2.6
Nuclear risk[4]			
Revenues			
Directly related to a specific cost category			
Charges for infrastructure usage	594	651	881
Airport revenues			
Revenues flight control	155	159	151
Total	**749**	**810**	**1 032**
Loss of revenues due to tax exemptions[5]		-89.3	
Minaral oil tax	n.a.	-83.1	n.a.
VAT on mineral oil price	n.a.	-6.2	n.a.
Other transport specific revenues	0	0	0
Fuel tax			
VAT			
Subsidies			
Non-transport related revenues of airports[6]			

[1] Transport system external costs only: Included are those cost parts that are not borne by rail users and insurance companies of the rail sector but by the public sector and third parties. The transport system internal costs are given below under "Additional information". – [2] Emissions of particles not included. [3] Transit flights over Switzerland included. – [4] Because there is no standardised methodology for the calculation of these costs, the figures are approximate indications. – [5] Mineral oil tax and VAT on the mineral oil tax (negative entries because of zero taxes). – [6] It was not possible to subdivide costs and revenues into flight related and non flight related parts.

Source: Suter et al. (2002)

The overall costs as assessed in this project amount to about € 1.1 billion. They are significantly lower than the costs of road and rail transport. By far the largest part of the costs is transport system internal. This is also a result of the fact that there are no "official" subsidies for aviation with the exception of the tax exemption of air transport fuel (see "losses of fiscal revenues ..." in the table above). Under the assumptions used in the calculations, congestion costs are higher than the environmental costs of aviation.

The total costs of aviation given in the table above tend to increase significantly between 1998 and 2005, namely almost 40% up to € 1.5 billion. This increase is the consequence of the considerable growth of the airport infrastructure costs (+38%), the congestion (user) costs (+112%) and of the environmental/climate costs (+43%).

Table 5-8 summarises the average costs per aircraft movement on the three national airports of Switzerland (Zurich, Geneva and Basle).

Table 5-8: Average cost rates for air transport in Switzerland 1998, in € / aircraft movement at the three airports Zurich, Geneva and Basle

	1998		
	Passenger	Cargo	Total
Core information			
Infrastructure costs [1]	1 484.10		1 484.10
Fixed			
Variable			
External accident costs [1]	18.85		18.85
Administrative	2.99		2.99
Health costs	0.16		0.16
Production loss	15.69		15.69
Environmental costs [1]	177.86		177.86
Air pollution	39.50		39.50
Global warming [2]	25.34		25.34
Noise	60.50		60.50
Total I	**1 680.80**		**1 680.80**
Additional information			
Delay costs [3]	300.92		300.92
Internal accident costs [1]	199.51		199.51
Administrative	17.08		
Health costs	0.30		
Material damages	59.30		59.30
Risk value	122.83		122.83
Environmental costs [1]	7.08		7.08
Nature, landscape, soil and water pollution [1]	7.08		7.08
Nuclear risk			0.00
Total II	**507.51**		**507.51**
Revenues [1]			
Charges for infrastructure usage	1 847.87		1 847.87
Airport revenues	1 486.88		1 486.88
flight control	360.99		360.99
Fuel tax			0.00
VAT [4]			0.00
Total	**1 847.87**		**1 847.87**
Subsidies			
Exemption for kerosene tax [5]	**203.89**		203.89
Total	**203.89**		**203.89**
Basic data			
Number of aircraft movements (3 national airports)	437 990		437 990
Passenger-kilometres (bill. pkm)	59.99	-	59.99
Tonne-kilometres (bill. tkm)	-	2.26	2.26

[1] No allocation to passenger/cargo possible. - [2] Only CO_2-emissions at the airports taken into account. - [3] Delay costs for cargo is not avialable. – [3] VAT on fuel tax. - [5] There is no tax on kerosene. The figures give the losses of fiscal revenues due to this tax exemption.

Source: Suter et al. (2002)

5.5 Swiss Inland Waterway Account

Table 5-9: Swiss inland waterway account for 1996, 1998 and 2005, € million, 1998 prices

Costs **Core information**	**1996**	**1998**	**2005**
Infrastructure costs – inland waterways			
Fixed			
Variable			
Infrastructure costs – inland waterway harbours	9.96	10.01	15.28
Fixed			
Variable			
Accident costs (external)			
Environmental costs			
Air pollution			
Global warming			
Noise			
Total	**9.96**	**10.01**	**15.28**
Additional information			
Congestion costs			
Accident costs (internal)			
From this: risk value			
Environmental costs			
Nature and landscape, soil and water pollution			
Nuclear risk			
Revenues			
Directly allocatable			
Charges for infrastructure usage			
Fixed			
Variable			
Inland waterway harbours[1)]	11.8	13.1	15.1
Total	**11.8**	**13.1**	**15.1**
Other transport specific revenues			
Fuel tax			
Eco tax			
VAT			
Subsidies[2)]	0.03	0.03	0.03
Non-transport related revenues of ports			

[1)] Subsidies and VAT are excluded. – [2)] Subsidies include the provision of infrastructure and are expressed in monetary terms.

Source: Suter et al. (2002)

The mode Inland Waterways only plays a very minor role if the territoriality principle is taken to assess costs - which is the case for UNITE. For Switzerland, this mode is limited to the harbours in the border town Basle. Therefore, the cost analysis concentrated on infrastructure costs and revenues of the two ports in Basle.

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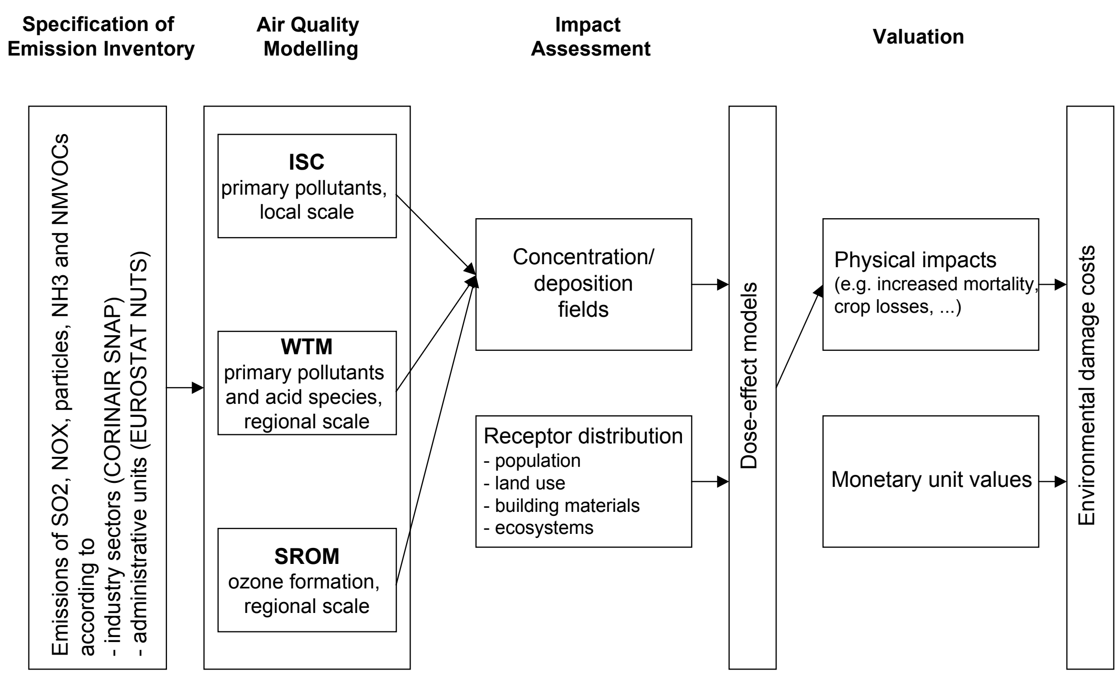
Annex

Description of the EcoSense Computer Model for Assessment of Costs due to Airborne Emissions

1 Model Description

The EcoSense model has been developed within the series of ExternE Projects on 'External Costs of Energy' funded by the European Commission (see e.g. European Commission, 1999a). The model supports the quantification of environmental impacts by following a detailed site-specific 'impact pathway' (or damage function) approach, in which the causal relationships from the release of pollutants through their interactions with the environment to a physical measure of impact are modelled and, where possible, valued monetarily. A schematic flowchart of the EcoSense model is shown in Figure 1. EcoSense provides harmonised air quality and impact assessment models together with a comprehensive set of relevant input data for the whole of Europe, which allow a site specific bottom-up impact analysis.

Figure 1: Flowchart of the EcoSense model



In ExternE, EcoSense was used to calculate external costs from individual power plants in a large number of case studies in all EU countries. While the first generation of the EcoSense model was focused on the analysis of single emission sources, the new 'multi-source' version of the model provides a link to the CORINAIR database, which allows the analysis of environmental impacts from more complex emission scenarios. The CORINAIR database provides emission data for a wide range of pollutants according to both a sectoral ('Selected Nomenclature for Air Pollution' - SNAP categories) and geographic ('Nomenclature of Territorial Units for Statistics' - NUTS categories) disaggregation scheme (McInnes, 1996). A transformation module implemented in EcoSense supports the transformation of emission data between the NUTS administrative units (country, state, municipality) and the grid system required for air quality modelling (EMEP 50 x 50 km^2 grid). Based on this functionality, EcoSense allows a user to change emissions from a selected sector (e.g. road transport) within a specific administrative unit, creates a new gridded European-wide emission scenario for air quality modelling, and compares environmental impacts and resulting damage costs between different emission scenarios. In other words, environmental damage costs are calculated by comparing the results of two model runs:

- A model run using the 'full' European emission scenario as an input to air quality and damage modelling, including emissions from all emission sources in Europe, as well as the emissions from the transport sector considered.
- A second model run in which the emissions from the transport sector considered were set to zero.

The difference in impacts and costs resulting from the two model runs represents the damages due to the transport sector considered.

In addition to these Europe-wide impacts local scale impacts were quantified using a Geographical Information System and spatially highly disaggregated data.

The following sections give a description of the relevant input data and the functionality of the models used in the different EcoSense sub-modules.

1.1 The EcoSense database

The EcoSense database provides various data sets required as input data by the different models integrated into the system. Table 1 gives a summary of the data categories available in the database, and the respective data sources.

Table 1: Environmental data available in the EcoSense database

	Resolution	Source
Receptor distribution		
Population	administrative units, EMEP 50 grid	EUROSTAT REGIO Database, The Global Demography Project
Production of wheat, barley, sugar beat, potato, oats, rye, rice, tobacco, sunflower	administrative units, EMEP 50 grid	EUROSTAT REGIO Database, FAO Statistical Database
Inventory of natural stone, zinc, galvanized steel, mortar, rendering, paint	administrative units, EMEP 50 grid	Extrapolation based on inventories of some European cities
Critical Loads/Levels for nitrogen-deposition for various ecosystems	EMEP 150 grid	UN-ECE
Meteorological data		
Wind speed	EMEP 50 grid	European Monitoring and Evaluation Programme (EMEP)
Wind direction	EMEP 50 grid	European Monitoring and Evaluation Programme (EMEP)
Precipitation	EMEP 50 grid	European Monitoring and Evaluation Programme (EMEP)
Emissions		
SO_2, NO_x, NH_3, NMVOC, particles	administrative units, EMEP 50 grid	CORINAIR 1994/1990, EMEP 1998 TNO particulate matter inventory (Berdowski et al., 1997)

1.1.1 Receptor data

Population data
Population data for most of the European countries are taken from the EUROSTAT REGIO database (base year 1996), which provides data on administrative units (NUTS categories). For most countries, data are available on NUTS 3 level. For impact assessment, the receptor data are required in a format compatible with the output of the air quality models. Thus, population data are transferred from the respective administrative units to the 50 x 50 km^2 EMEP grid by using the transfer routine implemented in EcoSense.

Crop production
The following crop species are considered for impact assessment: barley, oats, potato, rice, rye, sunflower seed, tobacco, and wheat. Data on crop production are again taken from the EUROSTAT REGIO database for most of the European countries (base year 1996). For impact assessment, crop production data are transferred from the administrative units to the EMEP 50 x 50 km^2 grid.

Material inventory
The following types of materials are considered for impact assessment: galvanised steel, limestone, mortar, natural stone, paint, rendering, sandstone, and zinc. As there is no database available that provides a full inventory of materials for Europe, the stock at risk for Europe was extrapolated in ExternE from detailed studies carried out in several European cities.

Critical loads for ecosystems

The EcoSense database provides critical load data for acidification and eutrophication for a wide range of ecosystems from the UN-ECE Coordination Center for Effects for the year 1997 (Posch et al., 1997). The spatial resolution of critical load data is 150 x 150 km.

1.1.2 Emission data

As the formation of secondary pollutants like ozone or secondary particles heavily depends on the availability of precursors in the atmosphere, the EcoSense database provides a European wide emission inventory for SO_2, NO_x, NH_3, NMVOC, and particles as an input to air quality modelling. As far as available, EcoSense uses data from the EMEP 1998 emission inventory (Richardson 2000, Vestreng 2000, Vestreng and Støren 2000). Where required, data from the CORINAIR 1994 inventory. (http://www.aeat.co.uk/netcen/corinair/94/) and the CORINAIR 1990 inventory (McInnes, 1996) are used. For Russia, national average emission data from the LOTOS inventory (Builtjes, 1992) were included. Emission data for fine particles are taken from the European particle emission inventory established by Berdowski et al. (1997).

1.1.3 Meteorological data

The Windrose Trajectory Model (see below) requires annual average data on wind speed, wind direction, and precipitation as an input. The EcoSense database provides data from the European Monitoring and Evaluation Programme (EMEP) for the base year 1998.

1.2 Air quality models

To cover different pollutants and different scales, EcoSense provides three air quality models completely integrated into the system:

- The Industrial Source Complex Model (ISC) is a Gaussian plume model developed by the US-EPA (Brode a. Wang, 1992). The ISC is used for transport modeling of primary air pollutants from point sources on a local scale. Within UNITE local scale effects were quantified in a GIS environment, so that the ISC model was not used here.
- The Windrose Trajectory Model (WTM) (Trukenmüller et al., 1995) is used in EcoSense to estimate the concentration and deposition of acid species on a regional scale. It was originally developed at Harwell Laboratory by Derwent and Nodop (1986) for atmospheric nitrogen species, and extended to include sulphur species by Derwent, Dollard and Metcalfe (1988). The model is a receptor-orientated Lagrangian plume model employing an air parcel with a constant mixing height of 800 m moving with a representative wind speed. The results are obtained at each receptor point by considering the arrival of 24 trajectories weighted by the frequency of the wind in each 15° sector. The trajectory paths are assumed to be along straight lines and are started at 96 hours from the receptor point.
- The Source-Receptor Ozone Model (SROM), based on the EMEP country-to-grid matrices (Simpson et al., 1997), is used to estimate ozone concentrations on a European scale. The Source-Receptor Ozone Model (SROM) integrated in the EcoSense package is based on source-receptor relationships from the EMEP MSC-W oxidant model for five years of meteorology (Simpson et al., 1997). It is used to estimate ozone concentrations on a European scale. Input to SROM are national annual NO_x and anthropogenic NMVOC emis-

sions data from 37 European countries, while output is calculated for individual EMEP 150x150 km^2 grid squares by employing country-to-grid square matrices. To account for the non-linear nature of ozone creation, SROM utilises an interpolation procedure allowing source-receptor relationships to vary depending upon the emission level of the country concerned (Simpson and Eliassen, 1997, Appendix B).

1.3 Dose-effect models

The approach for impact assessment follows the approach established in ExternE. Dose-effect models have been compiled and critically reviewed by expert groups within the ExternE project. A detailed discussion of the effect mechanisms, underlying assumptions etc. is given in (European Commission, 1999a). The dose-response functions are used here according to the final recommendations of the expert groups in the final phase of the ExternE Core/Transport project (Friedrich and Bickel, 2001). The following sections give a summary of the dose-response functions as they are implemented in the EcoSense version used for this study. The exceedance of critical loads for acidification and eutrophication is an impact category that was not addressed in ExternE because the implementation of the critical load module in EcoSense has been finished very recently only.

Table 2: Health and environmental effects included in the analysis

Impact category	**Pollutant**	**Effects included**
Public health – mortality	$PM_{2.5}$, PM_{10} [a]	Reduction in life expectancy due to acute and chronic mortality
	SO_2, O_3	Reduction in life expectancy due to acute mortality
Public health – morbidity	$PM_{2.5}$, PM_{10}, O_3	respiratory hospital admissions
		restricted activity days
	$PM_{2.5}$, PM_{10} only	cerebrovascular hospital admissions
		congestive heart failure
		cases of bronchodilator usage
		cases of chronic bronchitis
		cases of chronic cough in children
		cough in asthmatics
		lower respiratory symptoms
	O_3 only	asthma attacks
		symptom days
Material damage	SO_2, acid deposition	Ageing of galvanised steel, limestone, natural stone, mortar, sandstone, paint, rendering, zinc
Crops	SO_2	Yield change for wheat, barley, rye, oats, potato, sugar beet
	O_3	Yield loss for wheat, potato, rice, rye, oats, tobacco, barley, wheat
	Acid deposition	increased need for liming
	N, S	fertilisational effects
Exceedance of critical loads for acidification and eutrophication	N, S	ecosystem area in which critical loads are exceeded

[a] including secondary particles (sulfate and nitrate aerosols)

1.3.1 Exposure-response functions for the quantification of health effects

The following Table 3 lists the exposure response functions used for the assessment of health effects. The exposure response functions are taken from the 2nd edition of the ExternE Methodology report (European Commission, 1999a), with some small modifications resulting from recent recommendations of the health experts in the final phase of the ExternE Core/ Transport project (Friedrich and Bickel, 2001).

Table 3: Quantification of human health impacts. The exposure response slope, f_{er}, has units of [cases/(yr-person-µg/m^3)] for morbidity, and [%change in annual mortality rate/(µg/m^3)] for mortality. Concentrations of SO_2, PM_{10} , PM_{10}, sulphates and nitrates as annual mean concentration, concentration of ozone as seasonal 6-h average concentration.Health and environmental effects included in the analysis

Receptor	Impact Category	Reference	Pollutant	f_{er}
ASTHMATICS (3.5% of population)				
Adults	Bronchodilator usage	Dusseldorp et al., 1995	PM_{10} Nitrates $PM_{2.5}$ Sul- phates	0.163 0.163 0.272 0.272
	Cough	Dusseldorp et al., 1995	$PM_{10,}$ Nitrates $PM_{2.5}$ Sul- phates	0.168 0.280 0.280
	Lower respiratory symptoms (wheeze)	Dusseldorp et al., 1995	PM_{10} Nitrates $PM_{2.5}$ Sul- phates	0.061 0.061 0.101 0.101
Children	Bronchodilator usage	Roemer et al., 1993	PM_{10} Nitrates $PM_{2.5}$ Sul- phates	0.078 0.078 0.129 0.129
	Cough	Pope and Dockery, 1992	PM_{10} Nitrates $PM_{2.5}$ Sul- phates	0.133 0.133 0.223 0.223
	Lower respiratory symptoms (wheeze)	Roemer et al., 1993	PM_{10} Nitrates $PM_{2.5}$ Sul- phates	0.103 0.103 0.172 0.172
All	Asthma attacks (AA)	Whittemore and Korn, 1980	O_3	4.29E-3
ELDERLY 65+ (14% of population)				
	Congestive heart failure	Schwartz and Morris, 1995	PM_{10} Nitrates $PM_{2.5}$ Sul- phates CO	1.85E-5 1.85E-5 3.09E-5 3.09E-5 5.55E-7
CHILDREN (20% of population)				
	Chronic cough	Dockery et al., 1989	PM_{10} Nitrates $PM_{2.5}$ Sulphates	2.07E-3 2.07E-3 3.46E-3 3.46E-3

Receptor	Impact Category	Reference	Pollutant	f_{er}
ADULTS (80% of population)				
	Restricted activity days (RAD)	Ostro, 1987	PM_{10} Nitrates $PM_{2.5}$ Sul- phates	0.025 0.025 0.042 0.042
	Minor restricted activity days (MRAD)	Ostro and Rothschild, 1989	O_3	9.76E-3
	Chronic bronchitis	Abbey et al., 1995	PM_{10} Nitrates $PM_{2.5}$ Sulphates	2.45E-5 2.45E-5 3.9E-5 3.9E-5
ENTIRE POPULATION				
	Chronic Mortality (CM)	Pope et al., 1995	PM_{10} Nitrates $PM_{2.5}$ Sulphates	0.129% 0.129% 0.214% 0.214%
	Respiratory hospital admissions (RHA)	Dab et al., 1996	PM_{10} Nitrates $PM_{2.5}$ Sulphates	2.07E-6 2.07E-6 3.46E-6 3.46E-6
		Ponce de Leon, 1996	SO_2 O_3	2.04E-6 3.54E-6
	Cerebrovascular hospital admissions	Wordley et al., 1997	PM_{10} Nitrates $PM_{2.5}$ Sulphates	5.04E-6 5.04E-6 8.42E-6 8.42E-6
	Symptom days	Krupnick et al., 1990	O_3	0.033
	Cancer risk estimates	Pilkington et al., 1997; based on US EPA evaluations	Benzene Benzo-[a]- Pyrene 1,3-butadiene Diesel particles	1.14E-7 1.43E-3 4.29E-6 4.86E-7
	Acute Mortality (AM)	Spix et al. / Verhoeff et al., 1996	PM_{10} Nitrates $PM_{2.5}$ Sulpha- tes	0.040% 0.040% 0.068% 0.068%
		Anderson et al. / Touloumi et al., 1996	SO_2	0.072%
		Sunyer et al., 1996	O_3	0.059%

Source: Friedrich and Bickel (2001)

1.3.2 Exposure-response functions for the quantification of impacts on crops

Effects from SO_2

For the assessment of effects from SO_2 on crops, an adapted function from the one suggested by Baker et al. (1986) is used as recommended in ExternE (European Commission, 1999a). The function assumes that yield will increase with SO_2 from 0 to 6.8 ppb, and decline thereafter. The function is used to quantify changes in crop yield for wheat, barley, potato, sugar beet, and oats. The function is defined as

$$y = 0.74 \cdot C_{SO2} - 0.55 \cdot (C_{SO2})^2 \qquad \text{for } 0 < C_{SO2} < 13.6 \text{ ppb}$$

$$y = -0.69 \cdot C_{SO2} + 9.35 \qquad \text{for } C_{SO2} > 13.6 \text{ ppb}$$

with y = relative yield change

C_{SO2} = SO_2-concentration in ppb

Effects from ozone

For the assessment of ozone impacts, a linear relation between yield loss and the AOT 40 value (Accumulated Ozone concentration above Threshold 40 ppb) is assumed. The relative yield loss is calculated by using the following equation, and the sensitivity factors given in Table 4:

$$y = 99.7 - \alpha \cdot C_{O3}$$

with y = relative yield change

= sensitivity factors

C_{O3} = AOT 40 in ppmh

Table 4: Sensitivity factors for different crop species

Sensitivity	α	Crop species
Slightly sensitive	0.85	rye, oats, rice
Sensitive	1.7	wheat, barley, potato, sunflower
Very sensitive	3.4	tobacco

Acidification of agricultural soils

The amount of lime required to balance acid inputs on agricultural soils across Europe is assessed. The analysis of liming needs should be restricted to non-calcareous soils, but the percentage of the agricultural area on non-calcareous soils has not been available Europe-wide. Thus, the quantified additional lime required is an over-estimation giving an upper limit to the actual costs. The additional lime requirement is calculated as:

$$\Delta L = 50 \cdot A \cdot \Delta D_A$$

with ΔL = additional lime requirement in kg/year

A = agricultural area in ha

ΔD_A = annual acid deposition in $meq/m^2/year$

Fertilisational effects of nitrogen deposition

Nitrogen is an essential plant nutrient, applied by farmers in large quantity to their crops. The deposition of oxidised nitrogen to agricultural soils is thus beneficial (assuming that the doseage of any fertiliser applied by the farmer is not excessive). The reduction in fertiliser requirement is calculated as:

$$\Delta F = 14.0067 \cdot A \cdot \Delta D_N$$

with ΔF = reduction in fertiliser requirement in kg/year

A = agricultural area in ha

ΔD_N = annual nitrogen deposition in meq/m²/year

1.3.3 Exposure-response functions for the quantification of material damage

For the assessment of material damage, a set of new exposure-response functions was recommended in the final phase of ExternE Core/Transport (Friedrich and Bickel, 2001), which differ from those described in the ExternE methodology report. The following exposure-response functions were used in this study:

Limestone:

surface recession: $R = (2.7[SO_2]^{0.48}e^{-0.018T} + 0.019Rain[H^+]) \cdot t^{0.96}$

maintenance frequency: $1/t = [\ (2.7[SO_2]^{0.48}e^{-0.018T} + 0.019Rain[H^+])/R\ ]^{1/0.96}$

with
- $1/t$ maintenance frequency in 1/a
- SO_2 SO_2 concentration in µg/m³
- T temperature in °C
- Rain precipitation in mm/a
- [H+] hydrogen ion concentration in precipitation in mg/l
- R surface recession in µm

Sandstone, natural stone, mortar, rendering:

surface recession: $R = (2.0[SO_2]^{0.52}e^{f(T)} + 0.028Rain[H^+]) \cdot t^{0.91}$

maintenance frequency: $1/t = [\ (2.0[SO_2]^{0.52}e^{f(T)} + 0.028Rain[H^+])/R\ ]^{1/0.91}$

with
- $1/t$ maintenance frequency in 1/a
- SO_2 SO_2 concentration in µg/m³
- T temperature in °C
- $f(T)$ $f(T) = 0$ if $T < 10$ °C; $f(T) = -0.013(T-10)$ if $T > 10$ °C
- Rain precipitation in mm/a
- [H+] hydrogen ion concentration in precipitation in mg/l
- R surface recession in µm

Zinc and galvanised steel:

mass loss: $ML = 1.4[SO_2]^{0.22}e^{0.018Rh}e^{f(T)}t^{0.85} + 0.029Rain[H^+]t$

with
ML mass loss in g/m^2
SO_2 SO_2 concentration in $\mu g/m^3$
Rh relative humidity in %
T temperature in ^oC
f(T) $f(T) = 0.062(T-10)$ if $T < 10\ ^oC$; $f(T) = -0.021(T-10)$ if $T > 10\ ^oC$
t time in years
Rain precipitation in mm/a
[H+] hydrogen ion concentration in precipitation in mg/l

maintenance frequency: $1/t = 0.14[SO_2]^{0.26}e^{0.021Rh}e^{f(T)}/R^{1.18} + 0.0041Rain[H^+]/R$

with
1/t maintenance frequency in 1/a
SO_2 SO_2 concentration in $\mu g/m^3$
Rh relative humidity in %
T temperature in ^oC
f(T) $f(T) = 0.073(T-10)$ if $T < 10\ ^oC$; $f(T) = -0.025(T-10)$ if $T > 10\ ^oC$
Rain precipitation in mm/a
[H+] hydrogen ion concentration in precipitation in mg/l
R surface recession in µm

Paint on steel:

maintenance frequency: $1/t = [\ (0.033[SO_2] + 0.013Rh + f(T) + 0.0013Rain[H^+])/5\ ]^{1/0.41}$

with
1/t maintenance frequency in 1/a
SO_2 SO_2 concentration in $\mu g/m^3$
Rh relative humidity in %
T temperature in ^oC
f(T) $f(T) = 0.015(T-10)$ if $T < 10\ ^oC$; $f(T) = -0.15(T-10)$ if $T > 10\ ^oC$
Rain precipitation in mm/a
[H+] hydrogen ion concentration in precipitation in mg/l
R surface recession in µm

Paint on galvanised steel:

maintenance frequency: $1/t = [\ (0.0084[SO_2] + 0.015Rh + f(T) + 0.00082Rain[H^+])/5\ ]^{1/0.43}$

with 1/t maintenance frequency in 1/a

SO_2 SO_2 concentration in µg/m^3

Rh relative humidity in %

T temperature in ^oC

f(T) f(T) = 0.04(T-10) if T < 10 ^oC; f(T) = -0.064(T-10) if T > 10 ^oC

Rain precipitation in mm/a

[H+] hydrogen ion concentration in precipitation in mg/l

R surface recession in µm

Carbonate paint:

material loss: $$\Delta d = 0{,}12 \cdot \left(1 - e^{\frac{-0{,}121 \cdot Rh}{100 - Rh}}\right) \cdot SO_2 + 0{,}0174 \cdot H^+$$

with Δd material loss in mm

SO_2 SO_2 concentration in µg/m^3

Rh relative humidity in %

H^+ hydrogen ion concentration in precipitation in mg/l

The critical thickness loss which triggers maintenance is 50 µm.

1.3.4 Acidification and eutrophication of ecosystems

There are no effect models available to quantify the expected damage to ecosystem resulting from the exceedance of critical loads. Therefore, such effects were not quantified in the present study.

1.4 Monetary values

The following table summarises the monetary values used for valuation of transboundary air pollution. According to Nellthorp et al. (2001) average European values should be used for transboundary air pollution costs, except for the source country, where country specific values were used. These were calculated according to the benefit transfer rules given in Nellthorp et al. (2001).

Table 5: Monetary values for health impacts (Euro$_{1998}$)

Impact	Monetary value (rounded)
Year of life lost (chronic effects)	75 000
Year of life lost (acute effects)	130 000
Chronic bronchitis	138 000
Cerebrovascular hospital admission	14 000
Respiratory hospital admission	3 600
Congestive heart failure	2 700
Chronic cough in children	200
Restricted activity day	100
Asthma attack	70
Cough	34
Minor restricted activity day	34
Symptom day	34
Bronchodilator usage	32
Lower respiratory symptom	7

Source: own calculations based on Friedrich and Bickel (2001) and Nellthorp et al. (2001)

2 Discussion of uncertainties

In spite of considerable progress made in recent years the quantification and valuation of environmental damage is still linked to significant uncertainty. This is the case for the Impact Pathway Methodology as well as for any other approach. While the basic assumptions underlying the work in ExternE are discussed in detail in (European Commission, 1999a), below an indication of the uncertainty of the results is given as well as the sensitivity to some of the key assumptions.

Within ExternE, Rabl and Spadaro (1999) made an attempt to quantify the statistical uncertainty of the damage estimates, taking into account uncertainties resulting from all steps of the impact pathway, i.e. the quantification of emissions, air quality modelling, dose-effect modelling, and valuation. Rabl and Spadaro show that - due to the multiplicative nature of the impact pathway analysis - the distribution of results is likely to be approximately lognormal, thus it is determined by its geometric mean and the geometric standard deviation σ_g. In ExternE, uncertainties are reported by using uncertainty labels, which can be used to make a meaningful distinction between different levels of confidence, but at the same time do not give a false sense of precision, which seems to be unjustified in view of the need to use subjective judgement to compensate the lack of information about sources of uncertainty and probability distributions (Rabl and Spadaro, 1999). The uncertainty labels are:

A = high confidence, corresponding to σ_g = 2.5 to 4;
B = medium confidence, corresponding to σ_g = 4 to 6;
C = low confidence, corresponding to σ_g = 6 to 12.

According to ExternE recommendations, the following uncertainty labels are used to characterise the impact categories addressed in this report:

Mortality:	B
Morbidity:	A
Crop losses:	A
Material damage:	B.

Besides of the statistical uncertainty indicated by these uncertainty labels, there is however a remaining systematic uncertainty arising from a lack of knowledge, and value choices that influence the results. Some of the most important assumptions and their implications for the results are briefly discussed in the following.

- **Effects of particles on human health**
  The dose-response models used in the analysis are based on results from epidemiological studies which have established a statistical relationship between the mass concentration of particles and various health effects. However, at present it is still not known whether it is the number of particles, their mass concentration or their chemical composition which is the driving force. The uncertainty resulting from this lack of knowledge is difficult to estimate.

- **Effects of nitrate aerosols on health**
  We treat nitrate aerosols as a component of particulate matter, which we know cause damage to human health. However, in contrast to sulphate aerosol (but similar to many other particulate matter compounds) there is no direct epidemiological evidence supporting the harmfullness of nitrate aerosols, which partly are neutral and soluble.

- **Valuation of mortality**
  While ExternE recommends to use the *Value of a Life Year Lost* rather than the *Value of Statistical Life* for the valuation of increased mortality risks from air pollution (see European Commission, 1999a for a detailed discussion), this approach is still controversially discussed in the literature. The main problem for the *Value of a Life Year Lost* approach is that up to now there is a lack of empirical studies supporting this valuation approach.

- **Impacts from ozone**
  As the EMEP ozone model, which is the basis for the Source-Receptor Ozone Model (SROM) included in EcoSense does not cover the full EcoSense modelling domain, some of the ozone effects in Eastern Europe are omitted. As effects from ozone are small compared to those from other pollutants, the resulting error is expected to be small compared to the overall uncertainties.

- **Omission of effects**
  The present report is limited to the analysis of impacts that have shown to result in major damage costs in previous ExternE studies. Impacts on e.g. change in biodiversity, potential effects of chronic exposure to ozone, cultural monuments, direct and indirect economic effects of change in forest productivity, fishery performance, and so forth, are omitted because they cannot be quantified currently.