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# STUDY OF METHODS OF ROAD CAPITAL COST ESTIMATION AND ALLOCATION BY CLASS OF USER IN AUSTRIA, GERMANY AND SWITZERLAND

**FINAL REPORT**

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**by**

**FRANZISKA BORER BLINDENBACHER**
**Economist - Transport Consultant**
**Bern, Switzerland**

**for**

**TRANSPORT CANADA**
**Economic Analysis Directorate**
**Ottawa, Canada**

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## TABLE OF CONTENTS

# INTRODUCTION

## 1. Background and Objectives

Transport Canada has recently initiated an Investigation of the Full Costs of Transportation. The initial work underway is compiling the financial costs at the national level in order to produce conceptual "national financial accounts" including the costs of the network infrastructure as well as commercial and private transport services. Allocation of the total road network costs by type of vehicle and functional class of road will be major subsequent tasks in the overall investigation. Such an allocation of road costs has never been undertaken comprehensively in Canada.

In other countries, considerable experience in the methods of allocation has been accumulated by transport authorities. In order to learn from their experiences, different road cost accounts produced in various countries (U.S.A., UK, Australia, etc.) will be reviewed and analyzed by Transport Canada.

The object of the current study is to prepare a **technical report explaining methodologies and data used by government authorities in the three German-speaking European countries of Austria, Germany and Switzerland** to estimate road infrastructure costs, by functional class of road, and allocate them by type of vehicle or user. (Contract No. T8080-04-0325, Appendix "A")

## 2. Structure of Report

The current technical report is divided in three parts. In **part A**, the methods applied in **Austria's new road cost account 2000 (WKR 2000)** are explained. **Part B** analyzes methods and data used in **Germany's new road cost account 2000**.
The last comprehensive road cost accounts of both countries dated back to 1990. In 2000, both, Austria and Germany produced new road cost accounts primarily in order to get a basis for calculating the rates of the planned road charges for heavy goods vehicles (HGV). Austria subsequently introduced a HGV-charge on certain limited-access highways in 2004, and Germany initiated charges for HGV on its limited-access highways early in 2005.
**Part C** reviews and summarizes the methodological aspects of the **Swiss road account**, including revisions of specific indicators and coefficients made in 2000. Switzerland is the only European country **updating its road account figures annually on a detailed basis** since the year 1959. Switzerland was also the first country in Europe to introduce a distance and emission related Heavy Vehicle Fee (HVF) on its entire road network in 2001.

Last but not least, it is important to remember, that there is no road cost account "per se". The methods used are always dependent on the goals intended to be achieved by a specific road cost account. (WKR 2003, p. 186)

# A. AUSTRIA

## 1. Introduction

In Austria, a road cost account study was carried out for the year 2000 (WKR 2003 by Dr. Max HERRY), mainly to update the road cost data compiled for the first time in 1990. On one hand, changes in the traffic (volume, composition), in transport legislation and in the general policy framework (EU membership: EU-Directives, political changes in Eastern Europe, the "new" ASFINAG: Motorways and Expressways Funding Corporation) had to be reflected, and on the other hand new road cost accounting methods had become available (especially for the calculation of the external and marginal costs). (WKR 2003, p. Z2)

The **Austrian road cost account 2000 (WKR 2000)** differs between the **Total road cost account** and the **Categories account**. Both are economic full cost accounts, whereas the account of the new road operating agency ASFINAG and its affiliates is prepared as a business account. (WKR 2003, p. 3)

The comparison of relevant costs with relevant revenues in the Total road cost account yielded **infrastructure cost recovery rates** (taking only infrastructure costs into account) as well as **total cost recovery rates** (taking infrastructure and external costs into account) for different types of roads and vehicles.

In the Categories account, the estimated infrastructure costs and revenues and the external accident and environment costs are allocated to different road categories and vehicle types.

The new road cost account **takes the external accident and environment costs into consideration**. For the first time, **calculations for the (social) marginal costs** were also carried out. The authors did not consider the results sufficiently plausible to be published; though they are considered as an important basis for forthcoming work in this field (see also UNITE A, D, CH). Consequently, they are not examined further in this report. (WKR 2003, p. Z 2)

## 2. Road infrastructure provision and operation

2.1 Total road costs account

In a "full-cost" road accounting, the following cost categories have to be estimated: **capital costs**, **current operating costs, external accident and external environment costs** (see annex A-1 for overview of accounting process). (WKR 2003, pp. 46)

2.1.1 Capital costs

Valuation of gross / net asset value 2000

Estimating **the gross and net asset value 2000,** a similar **synthetic approach** was applied as in 1990. In order to gather as much and as reliable information and data as possible, the road operating agency and its affiliates (ASFINAG) were asked to contribute intensively to the estimation of the asset value in 2000 (this was not the case in 1990). For the same purpose, a working group, consisting of members of the ministry, the agency and the study contractor was formed entitled to gather all the data needed. They created a data questionnaire supporting the reporting of the different institutions.

The road operators were asked to report **standard costs** referring to technical and legal standards of assets (not reconstruction costs to present-day prices) differentiated along construction groups

- for motorways and expressways per road section and road operator
- for federal roads the average of all federal roads per road operator

as well as **average life expectancies for construction elements and road types** (see below).

The standard costs had to be evaluated for motorways, expressways and federal roads for the following **construction elements** in order to be able to consider the different life expectancies of the construction elements for the calculation of the annual costs (see 2.3, annual depreciation)(WKR 2003, p. 48):

- Land purchase road assets
- Underground (earthwork, green care)
- Surface layer, protection layers (border lane and middle lane included)
- Surface layer, main course
- Slope protection (protection walls, etc.)
- Bridges, surface and underground
- Bridges, equipment
- Tunnel, construction
- Tunnel, equipment
- Noise protection
- Equipment (traffic signals, lightning, etc.)
- Operating facilities, land purchase
- Operating facilities, buildings
- Operating facilities, equipment

The result was the **gross asset value** (GAV) for the network valid on **1.1.2000** with prices of the year 1999 (VAT included), and differentiated after the three road types and the construction elements per road operator. (WKR 2003, p. 49)

The valuation of the asset value for state and municipal roads could not be done in the same comprehensive way. Instead, a total sum for each state was estimated, without differentiating into construction elements. Estimations of average costs per kilometer

were provided by road experts from each state, and multiplied by the state road network length to obtain the total network value. (WKR 2003, pp. 48)

**Depreciation, interests and interest rate**: The reinvestment values per construction element and road type were capitalized (see 2.3, depreciation). The land purchase is not depreciated, and only the interest costs are taken into the capital account.
The interest rate chosen is a **real interest rate** of 3.5%. (WKR 2003, pp. 56; see also 2.4, opportunity costs)

**"Time value"**: The valuation of the assets was done on the basis of **reinvestment prices (value as new)**. Because the actual existing state of the roads has to be allocated as costs to the users, the road network however, even by perpetual maintenance work normally can not be maintained to the values as new, a certain amount has to be deducted from the capital costs (evaluated to values as new) to get **"time values" of the capital costs**. The same procedure was done in the road cost account in 1990. Following percentages, differentiated by road types, have to be deducted from the reinvestment costs (value as new) to get the reinvestment costs to "time values":

- for motorways and expressways: 10%
- for federal roads: 15%
- for states and municipal roads: 20%

Concerning the above mentioned topic, there were different opinions around in the working group. Thus, the two possible options (value as new and time value) have been calculated in the study. The **main option** however is the one with the **costs expressed by time values**. (WKR 2003, p. 58)

**VAT**: The reinvestment values were evaluated with the VAT included. The VAT however is only considered in the road cost account if no pre-tax deduction can be made. For the reinvestment values of the motorways and expressways, which are in the hands of the operating agency ASFINAG, the VAT therefore had to be deducted. The agency is allowed to make these pre-tax deductions. For all other roads, the VAT is included in the road costs because no pre-tax deductions are allowed. The same principle was applied for the current operating costs. (WKR 2003, p. 58)

An alternative estimation of the asset value was carried out according to the **Perpetual Inventory Method, PIM.** However, because of a lack of long run investment data series, the results were of greater uncertainty than the results obtained with the above **synthetic approach used for the official road cost account**. (WKR 2003, pp. 59)

### 2.1.2 Current operating costs

For the annual **current operating costs,** detailed data were available. The following current operating costs had to be considered (WKR 2003, p. 64):

- general infrastructure (construction) maintenance
- general operating maintenance

- administration
- infrastructure (construction) maintenance for the road charging system
- operating expenditures for the road charging system

The VAT was taken into account in the same way as for the capital costs (see above).

### 2.1.3 External accident and environment costs

The methodological background for the external cost estimations as well as most of the necessary input data stem from various studies carried out in or for Austria. The data used for the Austrian road cost account 2000 (WKR 2000) are based on these study results in an updated and sometimes slightly adapted version. The data and methodologies applied and the new calculations are not treated further in this report, but the following notes and figures for 2000 are provided for information.

**External accident costs** are the monetary damages (bodily injuries and property damages) which are caused by accidents. The following cost elements are considered (WKR 2003, pp. 64):

- production losses
- medical costs
- administration costs
- "pretium vivendi" (losses through pain and sorrow)

Results for 2000 (in million Euro)(WKR 2003, p. 114):

- for motorways and expressways: 506
- for federal roads: 1,984
- for all roads: 4,861

**Noise costs** are the costs resulting from direct and indirect consequences of the noise of vehicles for each person and the society. Noise costs generally consist of two elements (WKR 2003, p. 77):

- Value by which assets are diminished (house prices etc.)
- Health damage and nuisance to humans

Results for 2000 (in million Euro)(WKR 2003, p. 114):

- for motorways and expressways: 450
- for federal roads: 413
- for all roads: 1,182

**External health costs** are costs produced by air pollution. The health costs considered in the road cost account 2000 are the damages due to PM10 (particulates of 10 mm or less). (WKR 2003, p. 80)

Results for 2000 (in million Euro)(WKR 2003, p. 114):

- for motorways and expressways: 535
- for federal roads: 534
- for all roads: 1,481

**Damages to buildings** are costs incurred by owners for cleaning and maintaining the buildings. They consist of two components (WKR 2003, p. 84):

- Additional cleaning costs
- Additional maintenance costs

Results for 2000 (in million Euro)(WKR 2003, p. 114):

- for motorways and expressways: 63
- for federal roads: 56
- for all roads: 162

**Damages to vegetation** are the monetized values of damage to nature and vegetation caused by toxic emissions, mostly damage to forests and agricultural harvest losses. (WKR 2003, p. 85)

Results for 2000 (in million Euro)(WKR 2003, p. 114):

- for motorways and expressways: 69
- for federal roads: 74
- for all roads: 200

**Climate costs** are the monetized values of global damages to the atmosphere of the earth, from road traffic primarily by CO2-emissions. (WKR 2003, p. 88)

Results for 2000 (in million Euro)(WKR 2003, p. 114):

- for motorways and expressways: 470
- for federal roads: 489
- for all roads: 1,337

**External accident costs 2000 for all roads (million Euro): 4,861**
**External environment costs 2000 for all roads (million Euro): 4,361**

**= Total external accident and environment costs for all roads: 9,222**

**Congestion costs** can be internal or external costs and were not considered in the road cost account 2000. (WKR 2003, p. 90)

## 2.2 Revenues

The **revenues** considered in the WKR 2000 are defined as extra charges recovered only from the group of road users and no other groups of the population. They consist of the following (with revenue recipient in brackets)(WKR 2003, pp. 93):

- revenues from the Vignette (ASFINAG)
- revenues from the tolled sections (ASFINAG)
- revenues from the STRABA (special road charge for heavy goods vehicles above 12 t; Federal Finance Ministry)
- revenues from mineral oil taxes, only road specific (financial equalization)
- revenues from heavy goods vehicle taxes (financial equalization)
- revenues from norm use charge (only for passenger cars; Federal Finance Ministry)
- revenues from motor related insurance taxes (financial equalization)

Based on these cost and revenue estimations, three different **cost recovery rates** were calculated (WKR 2003, p. 94):

- the cost recovery rate of the infrastructure account
- the cost recovery rate of the total cost account (considering external costs)
- the cost recovery rates of the categories account

## 2.3 Annual depreciation of the stock

The **reinvestment values per construction element and road type** were capitalized by the following formula:

$$Aij = WWij * Z * (1 + Z)\,nj / ((1 + Z)nj - 1)$$

A: capital costs per year (annuity)
WW: reinvestment values 2000
Z: interest rate
n: life expectancy
i: road (road section)
j: construction element

**Land purchase** is not depreciated. (WKR 2003, pp. 56)

## 2.4 Opportunity costs of invested capital

In the new road cost account WKR 2000, **reinvestment values in prices valid in 2000** were used. Therefore, a **real interest rate** of 3.5 % was chosen. It reflects the long run average of the Austrian government bonds and the annually increasing road construction price indices of the past 20 years. (WKR 2003, p. 56)

2.5 Expansions of the road network / capacity

Expansions of the road network or the capacity are taken into the road cost account by the same procedure as described in chapter 2, meaning that new road sections added to the network in 2000 were included in the total capital value of the network 2000, and their annual depreciation and opportunity costs were estimated by the same formula as described in 2.3 and 2.4.

## 3. Distribution of the road infrastructure costs by functional class of road

In Austria, five different road categories are differentiated:

- Motorways
- Expressways
- Federal roads
- States roads
- Municipal roads

Roads produce not only transport services, they serve for various non traffic-related purposes as well. Roads sometimes have a communication, military, regional and social function. A quantification of these functions is difficult to obtain and therefore rough estimations are used in Austria. The following percentages are subtracted from the estimated total road costs to reflect these alternative objectives (WKR 2003, p. 57, 95):

- Motorways and expressways: 0%
- Federal roads: 5%
- States and municipal roads: 10%

## 4. Cost / revenue allocation: Categories account

The estimated **infrastructure costs and revenues** are allocated on one hand to five different road categories (see chapter 3) and on the other hand to seven different vehicle types (see below).

The **external accident and environmental costs** are allocated only to three vehicle categories: passenger cars, coaches and heavy goods vehicles of at least 3.5 tonnes registered total weight (t rtw).

The main input data for the Categories account are the different “traffic performance characteristics”: the kilometers travelled per road category and vehicle type in 2000, the gross tonnage-kilometers and the axle-load-kilometers. (WKR 2003, pp. 96)

## 4.1 Cost allocation

In Austria, seven vehicle types are differentiated.

Vehicle types

- Passenger cars with / without trailer, or light goods vehicles (up to 3.5 tonnes registered total weight (t rtw))
- Coaches (from 3.5 t rtw upwards)
- Heavy goods vehicles (3.5 t to 7.5 t rtw)
- Heavy goods vehicles (7.5 t to 12 t rtw)
- Heavy goods vehicles (12 t to 18 t rtw)
- Heavy goods vehicles (18 t to 28 t rtw)
- Heavy goods vehicles (from 28 t rtw upwards)

The category of heavy goods vehicles contains straight trucks, trucks and trailers and articulated trucks. (WKR 2003, pp. 95)

### 4.1.1 Capital cost allocation

The capital costs had to be allocated to road categories and vehicle types.
The **allocation to road categories** could be done easily with the delivered input data (see above, chapter 2).

The **allocation to vehicle types** was done by an econometric approach using **multiple regressions**. The allocation **method used in Austria is an exception to the methods used generally in Europe**. Through multiple regressions, an explanation for differences in capital costs by road section due to differences in traffic composition by different vehicle types is searched for.

The estimated capital costs of a road section are compared to the corresponding traffic performances in vehicle-kilometers, gross tonnage-kilometers and axle-load-kilometers by vehicle type and year (time series analysis of traffic performance and annual costs). (WKR 2003, p. 97; Prognos/IWW 2002, p. 22)

Different methods of regressions were tested and the most reliable one chosen was the **method of single regressions** (standardized to the origin point). With the single regression method, the results of the single regressions have to be consolidated. This was done in various working steps. The result was the **allocation key** for the **capital costs** (see annex A-2, WKR 2003, p. 100, Tab. 46).

### 4.1.2 Current cost allocation

The allocation of the current operating costs to road categories could be calculated easily with the delivered input data (see chapter 2).

For the allocation of the current costs to the different vehicle types, the same econometric approach was applied as for the capital costs. The result was the **allocation key** for the **current operating costs** (see annex A-3, WKR 2003, p. 101, Tab. 47)

### 4.1.3 External accident and environment cost allocation

The external accident and environment costs were allocated to road categories and vehicle types as well. The allocation could not be done in such an elaborate manner as for the capital costs. These costs were allocated only to the three vehicle categories of passenger cars, coaches and heavy goods vehicles of at least 3.5 t rtw.

For the accident costs, the allocation to road categories was done using the results of the accident costs account, while for the environmental costs the allocation was by the traffic performance (vkm) of the different vehicles on the various road categories. (WKR 2003, pp. 103)

## 4.2 Revenue allocation

**Vignette revenues**: The vignette is valid only for motorways and expressways and there are different vignette types for the various types of vehicles. Therefore, a detailed allocation of the revenues to vehicle types already exists. Within the road categories, the revenue allocation is done by vehicle types according to the traffic performance (vkm).

**Road charged sections revenues**: Allocation to road sections exists already. ASFINAG calculated a key for the revenue allocation to vehicle types.

**STRABA revenues**: The STRABA has to be paid by heavy goods vehicles above 12 t rtw. The revenue allocation to road categories is done by the traffic performance (vkm) of the different types of heavy goods vehicles.

**Mineral oil taxes revenues** (only road-specific): Different calculation steps are necessary for diesel and gasoline, because they have different tax rates. The allocation to road categories is done by the traffic performance (vkm) of the different vehicle types.

**Heavy goods vehicle tax revenues**: This applies only to vehicles above 3.5 t rtw. Revenues are allocated correspondingly to vehicle types. The allocation to road categories is done by the traffic performance (vkm).

**Norm use charge revenues**: Applies only for passenger cars. Allocation to road categories is done by the traffic performance (vkm).

**Motor related insurance taxes revenues**: Applies only for passenger cars. The allocation to road categories is done by the traffic performance (vkm). (WKR 2003, pp. 103)

4.3 Formulae

The exact formulae for the cost allocation to vehicle types are not available. The method used is the **method of single regressions, standardized to the origin point.** The results gained by the single regressions have to be consolidated in various working steps. **By using this method, they search for an explanation for the road section specific capital costs by the road section specific traffic performances (vkm) of the different vehicle types.** (WKR 2003, pp. 97)

For the allocation key of the capital costs see annex A-2 and of the current operating costs see annex A-3. The annexes A-4 to A-7 show the results of the Austrian road cost account 2000.

## 5. Sources of main data, procedures for national compilation

The national compilation of all data for the Austrian road cost account 2000 (WKR 2000) was done by the study contractor.

A working group, consisting of members of the ministry, the road operating agency and the study contractor was formed and entitled to gather the data needed. A data questionnaire was created supporting the detailed reporting of the different institutions. (WKR 2003, p. 46)

For the current operating costs, detailed data were available from the road operating agency and its affiliates, the Federal Road Administration and the validation of the data for states and municipal roads was done by experts of the state governments. (WKR 2003, p. 64)

The revenue data of 2000 stem from the budgets of the Federal Finance Ministry and the road operating agency ASFINAG and its affiliates. (WKR 2003, p. 93)

## B. GERMANY

### 1. Introduction

The German Federal Ministry for Transport, Building and Housing (BMVBW) engaged a work group in 2001 to produce a **new road cost account for the federal road network (motorways, primaries)** (WKR 2000 by work group Prognos/IWW, WKR 2002). The new road cost account had to be developed in order to serve as a basis for the calculation of the charge for heavy goods vehicles (HGV, 12 tonnes and upwards) on limited-access highways introduced at the beginning of 2005 and called "Lkw-Maut".

Two main conditions had to be followed and were decisive for the choice of the **new methodology**: First, the assumption that German roads are operated by a public enterprise, obliged to cover all its expenditures. Second, the EC-Directive 1999/62/EC had to be respected. In this directive, the European Commission states that average infrastructure costs have to be the reference point for the rates of possible road charges. The road charges for HGV may vary according to weight, axle configuration and emission standards of the vehicles, and by the time of day within given ranges. But the total revenues of the road charges may not surpass the total infrastructure costs. (WKR 2002, pp. Z-1)

For the first time in Germany, a **synthetic process** has been carried out for estimating the road costs. In a first step, the **total costs** of the federal motorways and federal roads (primaries) have been estimated **for road sections** and **construction elements** for the years 2000 (basic year), 2003, 2005 and 2010. In a second step, in the **allocation account**, the estimated total costs have been **allocated to 6 different vehicle categories according to road sections, construction elements and cost categories** based on the "cost causation principle" and the "cost responsibility principle".

The former official methodology dated back to 1969, referring to studies by the "road costs" work group of the Federal Ministry for Transport and the German Institute for Economic Research, DIW, which was applied every three years between 1971 and 1991. For the new purpose of determining road user charges, the results of these studies had to be revised because the historical approach did not take into account the current infrastructure condition. (WKR 2002, p. 159, p.139)

The new German road cost account WKR 2000 does not include **external costs**. It limits itself strictly to the goal of covering the infrastructure costs in the long run. It is a full cost account and allocates the total costs to the users. The road user charges based on these calculations that were recently introduced had to be fair and efficient. (WKR 2002, p. Z-13)

## 2. Road infrastructure provision and operation

The **most important basic elements of the new methodology** applied are the following (WKR 2002, pp. 31):

1. Valuation of assets by reinvestment values in a basic year

The costs of construction elements needed for the estimation of the gross asset value are based on detailed analysis of project costs from new or enlarged infrastructure projects that were completed recently or planned for imminent implementation. They do not base on historical expenditure data. Through this method, it is possible to calculate the actual market value of the road network considering technical (new construction methods, etc.) and ecological development (new measures for environment protection, mitigation measures, etc.).

The net asset values for the base year 2000 are derived from these by using data about the current condition of the layers of each section of the federal road network (road surface roughness measurement). These data are provided by regular quality measurements of the entire federal road network (ZEB). The latest update of the database (1998) was used in the study.

2. Economic depreciation

The concept of economic depreciation - the reduction in remaining service value of the assets - was applied for the first time. It is a very flexible concept, and can be represented by many different functional forms of reductions in asset values over their lifetimes. (WKR 2002, p. 59)

This approach estimates the remaining value for each day of the entire lifetime of an asset taking into consideration actual information of that day. This is done for the whole economical life cycle of an asset. The annual depreciation results by comparing the differences of the values of the same day in consecutive years. The total amount of all annual depreciations is the initial asset value at the time of its installation.

3. Load-related wear and tear

The construction elements “surface” and “binder course” are depreciated in a load-related manner within this new method. For these two construction elements the functional relation between use and wear of highly and averagely frequented sections is given. By applying a load-related depreciation method, it is assured that the necessary improvement work for increasing traffic can be calculated accordingly and quickly.

4. Road section-related cost accounting

Infrastructure costs depend to a large extent on regional factors such as land purchase costs, number of tunnels, bridges etc. Furthermore, traffic activities differ a lot on the different road sections. Important uncertainties in the estimation of road costs and cost allocation can be reduced through the combination of road section-related costs and the consideration of detailed construction elements. In the WKR 2000, the German motorway network has been subdivided into 13,000 sections and the federal roads (primaries) have been disaggregated into more than 100,000 sections.

5. Compatibility with the Federal Road Planning / Investment Plan (BVWP) and maintenance costs accounting

The underlying road networks, traffic activity and cost rates for the infrastructure and operating maintenance are compatible with the forecast scenario of the Federal Transport Investment Plan (BVWP) made by the Federal Ministry for Transport, Building and Housing (BMVBW).

6. Cost allocation among vehicle types by "cost causation principle" and "cost responsibility principle"

The new road cost account uses an engineering approach for the cost allocation by type of vehicle.

Applying the "**cost causation principle"**, a direct relation between traffic activity and resulting costs has to be made. This can be done for the wear and tear directly caused by the use of the roads. Maintenance and some share of investment costs of surface layers are allocated accordingly by the $4^{th}$ power of axle weights as recommended by the AASHTO Road Test.

The "**cost responsibility principle"** takes into account the different needs for the dimensioning of roads by the various user categories. It considers the thickness of several layers, the road width through a newly developed system of capacity equivalency values, the design of intersections and exit points and specific costs for the horizontal and vertical alignment of roads due to the requirements by specific vehicle types.

The residual general costs are allocated according to "assumptions" of fairness using equivalence factors for capacity needs and transport performance (in vkm) as allocation keys.

## 2.1 Total road costs account

The total of the road costs consists of **current operating and capital costs** (see annex D-1 for overview of accounting process).

### 2.1.1 Capital costs

**Current operating costs** are expenditures that are made within a time frame of a maximum of two years. These are costs for short term infrastructure construction maintenance, operating maintenance, administration, traffic police, and expenditures for the new road charging system (see 2.1.2 below).

**Capital costs** include **depreciation and interest costs**. Expenditures for **measures having an effect for more than two years** are defined as capital costs, raising the values of assets and allowing users to benefit for a long time. Therefore, these expenditures are depreciated over their total period of use. Furthermore, the calculated net asset value has to bear a notional interest charge, representing its effective financing costs. (WKR 2002, pp. 36)

For the estimation of the capital road costs of 2003, a nominal interest rate of 4 % is applied (see also 2.3). Total interest costs are obtained by multiplying the asset value by the relevant (nominal) interest rate.

The estimation of the total costs of the federal motorways and federal roads (primaries) is based on the physically existing road network and traffic volume of the year 2000. An **algorithm** is applied to estimate the depreciation, interest and current operating costs of the different construction elements (see below) added or lost until 2010.(see annex D-2 for overview of algorithm). (WKR 2002, p. 81)
**Economic input parameters** for the algorithm are: Capital (nominal) interest rate, price indices for construction and land stock prices and reinvestment costs.
**Traffic input parameters** are: Development of road networks, forecast of transport performance (vkm) per road section. (WKR 2002, pp. 83)

Construction elements

The definition of **construction elements** of the road infrastructure has a central meaning for the accounting of total road costs as well as for the allocation account.

**16 specific elements** have been assigned to **three groups of construction elements:**

**a. road sections** (land purchase, earthwork, surface structure, equipment, etc.)
**b. engineering installations** (bridges, tunnels, noise protection, etc.)
**c. nodal points** (= intersections and exit points) (additional land purchase, additional equipment, etc.) (WKR 2002, pp. 36)

Valuation of assets in basic year 2000
(WKR 2002, pp. 42)

1. Estimation of **gross asset value (GAV)**

The estimation of the gross asset value is based on reinvestment costs including a quality component. Reinvestment costs are defined as actual costs for planning and construction of a road section. Quality components are added costs due to technical development or higher safety or environmental standards which have to be considered in case available reinvestment cost values do not reflect the current state of technology or infrastructure quality.
Standard cost rates provided for several groups of German federal states and for different road construction and extension measures by the Federal Ministry for Transport, Building and Housing (BMVBW) are used for the calculation of the costs of installations along the road sections.

The gross asset value in 2000 is estimated on one hand according to construction elements and on the other hand according to road sections of the motorways. The road network underlying is the forecast scenario of the Federal Road Planning 2000 (BVWP).

The quantity of the construction elements of each road section is expressed by their surface ($m^2$ of ground purchase, tunnels and bridges), volume ($m^3$ of main, binder and surface course) or length (m of equipment and other engineering works).
Nodal points (intersections and exit points) are expressed by calculating their standard costs for different age classes and by allocating the vehicle kilometers to the sections of particular limited-access highways according to the specific density of the nodal points and the average age of the highways. All elements are differentiated according to regional conditions.

The descriptions of the road sections are taken from the database developed for the Federal Investment Plan 2003-2015 (BVWP). Additional data on road condition levels by federal state were assigned to the segment database by GIS information. For bridges, including bridge structures at nodal points a separate database containing information on size and quality standard was provided by BMVBW. The quantity and type of nodal points were extracted from road maps.

2. Estimation of **net asset value (NAV)**

The net asset values for the base year 2000 are derived from these by using data on the current condition of the structural layers of each section of the federal road network. The data are provided by regular quality measurements of the entire federal road network (ZEB). The latest update of the database for the year 1998 was used in the study. Each section is ranked between 1 (very good) and 5 (to be replaced immediately). The net asset value in the base year is then determined by assuming that mark 1 corresponds to 100% of the gross asset value and that mark 5 means a NAV of zero.

The basis for the estimation of the net asset values of existing assets is the expected residual lifetime after depreciation by time and the expected future services of construction elements depreciated according to loads over time.

NAV of construction elements (NAV = GAV in t = 0) that are depreciated by time:

$$NAV = GAV * T_{res} / T_{total}$$

NAV of construction elements for which aging and loss are directly related to use and depreciation is load-related:

$$NAV = GAV * S_{res} / S_{total}$$

NAV : net asset value

GAV : gross asset value

$T_{res}$ : expected residual lifetime

$T_{total}$ : average total lifetime of construction element

$S_{res}$ : expected residual service

$S_{total}$ : total average service of construction element

Distributions are estimated of expected residual lifetime or expected future services of assets. A practical statistical measurement is the median. Information about age and aging as well as condition or quality of the infrastructure is needed. (WKR 2002, p. 44)

**Total costs according to construction elements (WKR 2002, pp. 92):**

a. Total costs of road sections

**Land purchase** costs are not depreciated. The capital costs therefore consist of the interest costs on the gross asset value. Standard cost rates for land purchase are evaluated, differentiated by regional and geographical aspects.

**Earthwork**: Standard costs are calculated depending on topography, the number of lanes and the existence of a roadway "shoulder".

**Superstructure**: Standard cost rates for asphalt construction are evaluated depending on number of lanes and regional aspects. NAV is estimated by GAV and information about aging and condition.

**Equipment:** Standard cost rates per kilometer are calculated. A depreciation period of 18 years is assumed.

b. Total costs of engineering installations

**Bridges:** Reinvestment costs are differentiated by area of bridge and type of construction. NAV is estimated by reinvestment costs and aging.

**Tunnels:** Reinvestment costs are dependent on the number of lanes, number of tubes and the type of construction. Standard cost rates are calculated.

c. Total costs of nodal points (intersections and exit points)

Reinvestment costs are estimated for **additional land purchase, additional equipment and additional earthwork.** The bridge structure of nodal points is contained in the bridge database provided by BMVBW and thus not calculated separately for the nodal points.

### 2.1.2 Current operating costs

**Current operating costs** consist of **measures with an impact for a maximum of two years** (WKR 2002, p. 64):

- periodical expenditures for road infrastructure construction maintenance
- expenditures for operating maintenance (winter service, green care)
- administration
- expenditures for traffic police control
- expenditures for road charging system

The expenditures for renewal work on tunnels and bridges are treated in a special way in the new road cost account. For these engineering installations, annual average expenditures for maintenance are estimated and then capitalized by annuity factors. Road maintenance is differentiated between operating maintenance and infrastructure maintenance. The latter is divided into construction maintenance, improvement and renewal.

Estimation and forecast of the current operating costs:

$$K_{lfd}(t) = K_{lfd}(T_A) \cdot \frac{NL(t)}{NL(T_A)} \cdot (1 + p_{Lohn})^{t-T_A}$$

$K_{lfd}(t)$ : current operating costs
$T_A$ : period of analysis
$NL(T_A)$ : length of federal highway network in year of analysis
NL(t) : length of federal highway network in year of forecast
$p_{Lohn}$ : annual growth of salaries and wages

2.2 Annual depreciation of the stock

Applying an **economic depreciation approach**, the periodical depreciation is done according to values of actual daily use or residual reinvestment values. The amounts of the periodical depreciation are the results of the development of the net asset value and the reinvestments. (WKR 2002, p. 64)

Calculation of amount of periodical depreciation:

DEP (t) = NV (t) – NV (t – 1) – R (t -1)

DEP (t) : depreciation in period t
NV (t) : net asset value at beginning of period t
R (t) : reinvestments made within period t

Land purchase costs are not depreciated.

2.3 Opportunity costs of invested capital

For the estimation of the capital costs of 2003, a **nominal interest rate** of 4 % is applied reflecting the opportunity costs of the invested capital.

2.4 Expansions of the road network / capacity

Expansions of the road network or the capacity are treated the same way as constructing new infrastructure. The costs are taken into account according to road sections, engineering installations and nodal points (see above, chapter 2).

## 3. Distribution of the road infrastructure costs by functional class of road

Two different categories of roads have been differentiated in the new road cost account WKR 2000: Federal limited-access highways and federal roads (primaries).

Concerning the definition of the road costs, the work group "road costs" of the Federal Ministry for Transport (1969) stressed the meaning of the "non traffic-related functions" of the roads. These are usually common communication functions of the interurban and local roads as well as the services of all roads for military and civilian purposes and tasks of common interests (police, rescue services etc.). This cost fraction is assumed to be negligibly small (= 0) for federal motorways and federal roads (primaries). Thus, all road costs occurring are taken into the total road cost account, no deductions have to be made. (WKR 2002, p. 40)

## 4. Cost / revenue allocation: Allocation account

### 4.1 Cost allocation

In the **allocation account**, the estimated total road costs are allocated to 6 different vehicle categories according to five allocation principles. (WKR 2002, p. 121)

Vehicle categories

- Passenger cars
- Motorcycles
- Coaches
- Light duty vehicles (LDV: <12t gross vehicle weight)
- Heavy goods vehicles (HGV: >= 12t gross vehicle weight)
- Other vehicles

**Road categories**: Through the bottom-up process of estimating the costs by road sections, a differentiation between federal motorways and federal primaries results automatically. (WKR 2002, pp. 67)

**Disaggregation according to vehicle categories**: In the first allocation step**,** the section-related road costs have to be differentiated for 21 different cost types by construction elements; while interest and depreciation costs are allocated separately.
In a second step, every cost segment is allocated totally or partially according to **five allocation principles**:

1. Costs that have to be allocated proportionally (in a linear way) to transport performance in vkm
2. System-specific costs of passenger cars
3. System-specific costs of trucks / heavy goods vehicles (with registered gross weight of 12 tonnes or more)

4. Capacity-related costs
5. Weight-related costs

The allocation of the costs segments of particular construction elements following the above-mentioned allocation principles is made according to engineering knowledge of road construction and maintenance as well as experience of experts in case of a lack of reliable data. It is done in a similar way in Switzerland. (WKR 2002, p. 68; Prognos 2002, p. 22)

If different allocation possibilities show up, maintenance costs of construction elements are treated and allocated separately than costs for new constructions. For reasons of simplifications it is assumed that the interest costs correspond to the costs of new construction while depreciation reflects the costs of maintenance and rehabilitation. (WKR 2002, p. 122; for overview see annex D-3, WKR 2002, p. 69, Abb. 3-12)

**Five allocation principles**

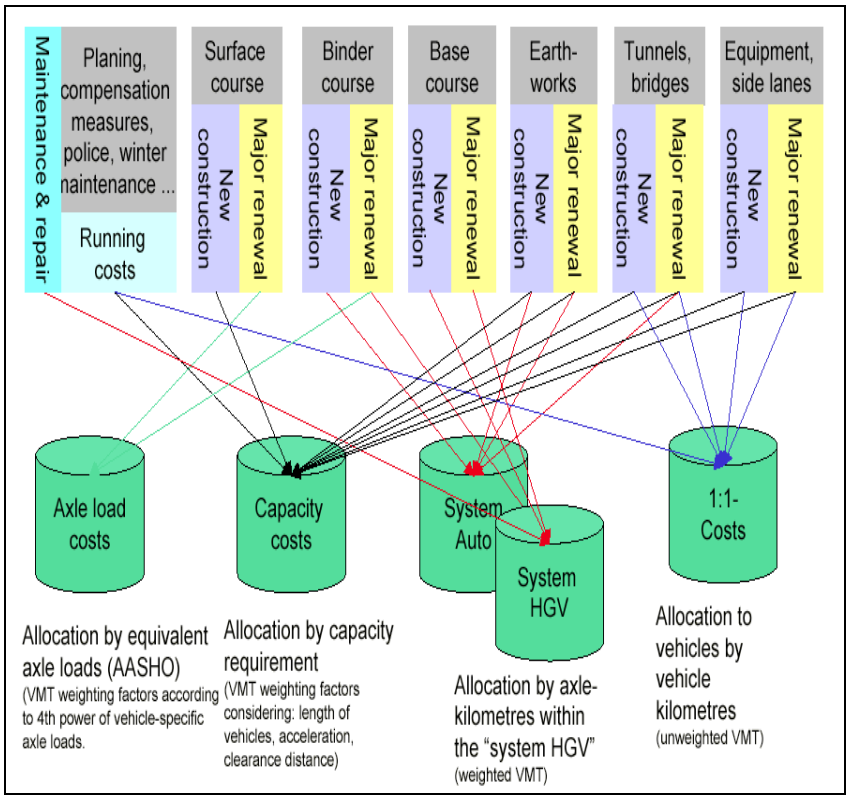
1. The **weight-related allocation key** primarily reflects the "**cost causation principle"**. The allocation to vehicle categories is done according to the known AASHO-functions by which the transport performance (vkm) is weighted (AASHO / AASHTO = American Association of State Highway and Transportation Officials). Maintenance and some share of investment costs of surface layers are allocated accordingly by the $4^{th}$ power of axle weights as recommended by the AASHO Road Test. The AASHO-function is only used for maintenance costs and not for new constructions. (WKR 2002, p. 70)

2. The **capacity-related** allocation principle is based on the thinking of the "**cost responsibility principle"**. For the allocation of the capacity costs, the transport performance (in vkm) of the different vehicle categories is weighted by **equivalence factors**. The factors used in Germany since 1969 have been updated to reflect new engine technologies giving HGV more dynamics in the traffic flow, and current driving habits (see annex D-4 for comparison of old and new equivalence factors). (WKR 2002, p. 134, Tab. 5-4; WKR 2002, pp. 129)

3. and 4. A potential new differentiation concerns the allocation of certain costs to a **specific vehicle system, the system for passenger cars or the system for trucks/heavy goods vehicles**. This approach is based on principles of the game theory. It requires separate planning and budgeting of alternative networks for passenger cars and trucks/heavy goods vehicles, which do not exist in Germany. A fair cost allocation might need this kind of information. There is a gap in knowledge and therefore a field for future engineering research. (WKR 2002, p. 71)

5. The fifth allocation principle is a **category-neutral allocation of costs**, in proportion to the transport performance (vkm). These are mainly common costs not related to any specific vehicle characteristics such as parts of the current operating costs, costs for certain engineering constructions etc.

An **overview of a rough assignment of construction elements to the five allocation principles** is shown below (WKR 2002, p. 73, Abb. 3-13). It is obvious, that there is not an exact assignment for each cost category to one or the other allocation principle. The detailed allocation is determined empirically and is shown in annex D-5, allocation scheme (allocation of construction element costs to allocation principles).




**Disaggregation of average costs according to the number of axles:** The cost allocation process only considered one category for all heavy vehicles of 12 t gross vehicle weight or more. According to the provisions of BMVBW, the costs were allocated to heavy vehicles according to three axle classes, where the difference from average costs was set by BMVBW. The three axle classes are:

- Two axles
- Three axles
- Four and more axles

This means that the differentiation by axle classes is not done according to any cost causation or cost responsibility criteria. Although the EC-Directive 1999/62/EC does not indicate a specific differentiation scheme, for equity reasons default settings have been applied in this study.

**Disaggregation according to emission classes:** follows the EC-Directive 1999/62/EC (see chapter 1) and is necessary for the calculation of the new road charge for heavy vehicles to enhance its environmental efficiency. The directive allows a maximum difference of charges of 50% between the lowest and the highest rate for particular vehicle types. This range was fully used by the study according to the requirements of BMVBW.

## 4.2 Revenue allocation

According to negotiations between the federal government and the representatives of the 16 federal states, the revenues from the road user charge (Lkw-Maut) are used as follows:

Approximately 20% are used to run the charge collection system, including enforcement and control of payments.
The remaining 80% are allocated as follows:
- 50% for construction and maintenance of the federal roads
- 38% for construction and maintenance of the federal railway network
- 12% for construction and maintenance of inland waterways.

## 4.3 Formulae

**Allocation algorithm**: A multistage process is used which requires disaggregations on different levels. First, the development of the transport performance (in vkm) has to be evaluated for the road and vehicle types. Second, accounting algorithms have to be generated for each allocation principle. The calibration of the coefficients has to be done in an empirical way. Third, **allocation rules** have to be generated, which define the share of the construction element costs being assigned to the five different allocation principles. This happens in an empirical way and is the **most sensitive part of the allocation account.**

The program algorithm (for cost estimation and allocation) was developed under the software ACCESS. For this purpose, information about traffic intensity per vehicle category and road sections was needed. It was delivered by the traffic simulation model for different time periods. (WKR 2002, pp. 113)

The exact formulae for the allocation algorithm (and the cost estimation algorithm) are not available. However, a detailed description of the procedure of how they were developed is given by the information above, the allocation scheme shown in annex D-5, the equivalence factors listed in annex D-4, and the results shown in annex D-6.

## 5. Sources of main data, procedures for national compilation

The Federal Ministry for Transport, Building and Housing (BMVBW) delivers the main data for the new road cost account WKR 2000. It produces the Federal Road Planning / Investment Plan (BVWP) which contains among other nationally compiled data figures about the length of the existing and future road network, actual and forecasted traffic volume for federal motorways and federal roads, cost standards for constructions etc.

The input data stem from various statistics produced by different institutions. (WKR 2002, pp. 81)

## C. SWITZERLAND

### 1. Introduction

In Switzerland, it is stipulated by a federal law that a road account has to be produced and published every year by the Swiss Federal Statistical Office, BFS (BFS, Rev 2000, p. 5). The road account has to be published according to four principles: First, fidelity to actual reality, second, consistency of the method, third, transparency for all, and fourth, credibility of the methods and results. (VW 10/92, p.63; BFS, Rev 2000, p. 5)

The Swiss road account differs between the **Global account** and the **Categories account**. Both are full cost accounts. (ARGE Herry/Infras/Prognos, 1994, p. 30; GVF Nr. 239, 1997).

The main goal of the official road account is to evaluate the **self-sufficiency of the Capital account** and the **cost recovery rate of the Expenditures account**. These are shown in the Global account.

Furthermore, costs and revenues are allocated to different types of vehicles for passenger, freight and heavy goods transport in the **Categories account** (see annex CH-1 for overview).

The **external costs** of road transport are **not yet included** in the official Swiss road account. However, they were estimated for the first time in 1993 and updated in 2000. The results served for the calculation of the rates of the **distance and emission related Heavy Vehicle Fee (HVF) introduced in 2001** (on the entire Swiss road network, involving area tolling, unique in Europe!). The following cost categories were considered (in million Swiss francs for 2000, where the currency exchange rate is approx. 1:1): Damage to buildings (245), noise (869), accidents (1433), health care (1525) and the new category of damage to nature and landscape (662;). (ARE, PM 2005; ARE, N&L 2004; ARE, Fair 2004, p. 9)

Most of the underlying methodologies date back to the overall revision of the Swiss road account in 1986 (Kommission Nydegger 1982). In 2000, particular changes were made especially concerning the applied axle-load factors. They are reflected in the actual study. (BFS, Rev 2000)

### 2. Road infrastructure provision and operation

Infrastructure includes roads, bridges and places open to public motorized traffic. Pedestrian sidewalks, tunnels and galleries, public parking lots, motorcycle and cycle paths, drainage and canalization of roads, street lightning and other engineering constructions for traffic are counted as well.

Infrastructure expenditures for motorized traffic to be incorporated in the accounts are decided by quotas in Switzerland. There are three different categories of roads, national, cantonal (equivalent to provincial in Canada) and municipal roads. The quotas for the expenditures taken into account are the following (see also chapter 3):

- for national roads: 100%
- for cantonal roads: 90 %
- for municipal roads: 70%

2.1 Total road costs: Global account

The Global account consists of the Capital account and the Expenditures account (see annex CH-2).

2.1.1 Capital account

The **Capital account** is a comparison of costs and imputable revenues reflecting the **rate of self-sufficiency, or cost recovery**. It shows how far the private motorized traffic covers the infrastructure costs it causes. (BFS, Rev 2000, p.6)

In the Capital account, road infrastructure is considered as an asset value which declines steadily over its period of use, whereas in the Expenditures account all investments of a particular year are assigned totally to that same year ("pay as you go"-system; see also 2.2 Depreciation of stock). (Kommission Nydegger 1982, p. 44)

**Costs**

In the Swiss road account, **capital costs are estimated by the perpetual inventory method, PIM,** using an average depreciation rate and interest rates based on government bonds. (UNITE CH, pp. 11)

The capital account is prepared according to business accounting. The relevant costs are the **capital costs,** meaning (i) the part of the **depreciation** on the cumulated declining balance of the road infrastructure investments by the end of the accounting year for infrastructure construction, enlargement, improvement and maintenance, and (ii) the **interest costs**, the imputed interest on the invested capital for road infrastructure in that same year. The interest rate is taken by the average government bond of the actual year (see also 2.3).

The **current or operating costs** are added to the capital costs. These are expenditures for operating maintenance, administration/personnel, signalization and traffic police control.

The comparison between the total of these costs with the imputable revenues gives the **rate of self-sufficiency**. The imputed interest of the cumulated deficits and surpluses since 1919 has to be added as well. (BFS, Rev 2000, p. 6; BFS, PM 2003, p. 10)

The **cost categories of the Capital account** for the three different road categories are (see annexes CH-3 and CH-4; BFS, PM 2003, p. 11):

- Value of land stock in 1919 (only existing for cantonal and municipal roads, see below)
- Cumulated land purchases (from 1919 to actual year)
- Declining balance of infrastructure construction and enlargement
- Declining balance of construction maintenance

= Total declining balance

- Interest on declining balance, at a rate of 4.3% in 2001
- Depreciation of infrastructure construction and enlargement
- Depreciation of construction maintenance

= Total capital costs (interests, depreciations)

- Current + operating costs

= Total road costs

- Quotas: 100% for national roads, 90% for cantonal and 70% for municipal roads

- Imputable costs (before interest on cumulated balances of deficits/surpluses)

The cost item "value of land stock 1919" (note: only for cantonal and municipal roads), is also called the "Legacy from the past" (Kommission Nydegger 1982, p. 51). Switzerland started publishing road accounts in 1959, dated back to the year 1919. The value of the road infrastructure taken into account in 1959 equaled the value of the land covered with roads in 1919: 120 million Swiss francs. (BFS, PM 2003, p. 11, see annex CH-3)

## Revenues

The different revenues come from the federal, cantonal and municipal level. They are attributed according to the principle of specific services (Kommission Nydegger 1982). Specific services of road traffic are charges or taxes on motorized traffic that surpass those on spending in other sectors. Only these specific services are considered as revenues in the road account. (BFS, PM 2003, pp. 6; BFS, PM 2004, p. 4; BFS, Rev 2000, pp. 21)

The ratio between general and specific services for the mineral oil taxes and the taxes on imports of vehicle and parts is fixed according to the official import statistics of the Swiss Federal Customs Administration (FCA). For the accounting of the revenues of the distance-related Heavy Vehicle Fee, the fraction for the decrease of the external costs included in this fee has yet to be subtracted from the total revenues. In the road account, only the part foreseen to cover the added expenditures for heavy vehicles (gross vehicle weight 3.5 tonnes upwards) has to be considered as revenue.

**The revenue categories** in the Swiss road account are (ARGE Herry/Infras/Prognos, 1994, p. 33; BFS, Rev 2000, pp. 21; GVF-Report 1/98, p. 42):

- Federal mineral oil taxes (gasoline, diesel)
- Supplementary charge on federal mineral oil taxes (gasoline, diesel)
- Taxes on imported vehicles and parts
- Attributable fraction of value added taxes VAT (see 2.1.2)
- Cantonal vehicle license taxes and charges
- Vignette (periodic permit for limited-access highway use by freight and passenger cars)
- Distance-related Heavy Vehicle Fee (HVF)

The revenue share of the federal mineral oil taxes (charge incl.) is about 63% in 2001. A further 24% comes from cantonal vehicle license taxes and charges. Taxes on imported vehicles and parts bring about 3 % of the revenues. The Vignette adds 4%, the distance-related Heavy Vehicle Fee (HVF) about 5% and the VAT 1%. (BFS, PM 2003, p. 7)

### 2.1.2 Expenditures account

In the **Expenditures account**, primarily a **liquidity account** (shows financial flow of public institutions for road infrastructure), the imputable revenues of a particular year (see above) are compared to the **real current road expenditures** of that same year (see annex CH-5). The positive and negative balances of all annual results since 1919 are cumulated and imputed with interest. The difference provides the **cost recovery rate**. (BFS, PM 2003, p. 10; BFS, Dumont et al. 2000 , pp. 7, 63; Kommission Nydegger 1982, p. 45)

**The gross expenditures** show the real expenditures for national, cantonal and municipal roads of one particular year before taking into account adjustments for VAT and quotas. Gross expenditures are especially used for cantonal road accounts and for the regionally allocation of the federal mineral oil taxes on gasoline and diesel.

**Net expenditures:** The **imputable expenditures** are calculated according to the net expenditures. Net means gross expenditures minus VAT minus expenditure shares (revenues from parking fees, revenues from third parties as military, Swiss National Post, etc.). For the municipal roads, 70% of the revenues stemming from public parking fees are deducted from the operating expenditures/costs and 30% from the investments. The net expenditures are especially suitable for comparisons between cantonal accounts on one hand and municipal accounts on the other hand. (BFS, PM 2003, pp. 9)

**VAT**: The general VAT rate, valid for road infrastructure as well, is defined by a federal law and has been 7.6% since 2001. In order to get the net expenditures, the **VAT (valid legal rate)** is subtracted from the **gross expenditures**.

For the calculation of the **VAT on the revenues**, a **weighted VAT rate** is applied because not all revenues (for example Vignette revenues, revenues from cantonal vehicle license taxes and charges) fall under this tax. The weighted VAT-rate is calculated annually on the base of the actual revenues of a particular year.

The **formula for the weighted VAT rate** is the following (BFS, PM 2003, pp. 7; BFS, VAT 2002):
(Revenues undergoing VAT * valid legal VAT rate) divided by imputable revenues before VAT

## 2.2 Annual depreciation of the stock

The Capital account takes into account the **amortization of the investment expenditures** in different periods along different types of expenditures (see section 2.1.1). It divides the expenditures in three categories with different amortization periods. This division follows the **account plan of the Swiss road account** (see annex CH-6; BFS, Dumont et al. 2000, pp. 8, 63):

- **Long run investment expenditures** which consist of the expenditures of the chapters 14 and 15 (infrastructure construction, enlargement, improvement and maintenance) without subchapters 147 and 157, 148 and 158. These expenditures, taken to the **value of the time of purchase (book value)** are depreciated straight-line over a period of 40 years by an annual rate of 2.5%.
- **Short run investment expenditures** which consist of the expenditures of chapter 13 (construction maintenance) without subchapters 138. These expenditures, taken to the **value of the time of purchase (book value**) are depreciated straight-line over a period of 12.5 years by an annual rate of 8.0%.
- **Current investment expenditures** which consist of the expenditures of the chapters 11, 12 and 17 as well as the subchapters deducted mentioned above. These expenditures are amortized totally in the current year.

The **land purchase** costs are not depreciated, neither is the "Legacy from the past" (see 2.1.1).

**Imputed interest**: The imputed interest is done according to the declining balance principle. That means, that the investment minus the cumulated depreciation is multiplied by the imputed interest rate (= average rate of government bonds). The imputed interest, according to the principle of declining balance, leads to a degressive capital cost curve when depreciated straight-line. (ARGE Herry/Infras/Prognos, 1994, p. 32)

## 2.3 Opportunity costs of invested capital

In the Swiss road account, the **capital costs** are evaluated according to the **value at the time of purchase of the investments (book value).** Because the value at the time of purchase (in contrast to reinvestment values) does not reflect the inflation between the

time of purchase and the actual time, there has to be a premium of inflation inherent in the interest rate of the capital being imputed. The base to that is a nominal interest. The **nominal interest reflects the opportunity costs of the tied capital.**

It is assumed that there has to be an interest on the total capital invested. A reasonable interest rate is the average return on investment of the government bonds because the investments are made for the public. The **average rate of government bonds** is estimated by a weighted average of the current government bonds (with different running periods and rates) and therefore varies from year to year. In 2001, it was 4.3% and 4.1% in 2002 (Switzerland is a low interest country). (BFS, Ueberpruefung Strassenrechnung, Infras, 2002, pp. 3; Kommission Nydegger 1982, p. 62)

In the Austrian and German road cost accounts, the capitalization is done on the basis of reinvestment values. Both countries are applying the interest rates of government bonds as well. But in general, they do not vary the interest rate as in Switzerland, instead usually adopting a fixed rate. (BFS, Ueberpruefung Strassenrechnung, Infras, 2002, pp. 4)

### 2.4 Expansions of the road network / capacity

Expansions of the road network or the capacity are treated the same way as new or improved infrastructure construction or maintenance (see 2.1.1, Capital account). The capital costs are taken into account as part of the depreciation on the cumulated declining balance of the road infrastructure investments by the end of the accounting year for infrastructure construction, enlargement, improvement and maintenance and for the interest costs, the imputed interest on the invested capital for road infrastructure is taken. (BFS, PM 2003, p. 10)

## 3. Distribution of the road infrastructure costs by functional class of road

The Swiss road account differentiates between three functional classes of roads:

- national roads
- cantonal roads
- municipal roads

The road account is based on the assumption that 100% of the costs of national roads, 90% of cantonal roads and 70% of municipal roads are related to motorized traffic, the rest to other purposes (non motorized use) like providing public places, space for pedestrians, bikes, etc. (ARGE Herry/Infras/Prognos, 1994, p. 31)

## 4. Cost / revenue allocation: Categories account

4.1 Cost allocation

Costs and revenues are allocated to different types of vehicles for passenger, freight and heavy goods transport in the **Categories account** (see annex CH-7).

The official Swiss road account lists cost categories and related revenues for 30 different vehicle types. Based on this information, the **cost recovery rate for each vehicle type** is shown in the **Categories account**.

Vehicle types

The 30 types of vehicles are divided into two vehicle categories (UNITE CH, pp. 11; ARGE Herry/Infras/Prognos, 1994, pp. 35; BFS, Rev 2000, p. 19):
a. passenger transport
b. freight transport

a. Passenger transport (8 types)
Motorcycles
Mopeds
Cars
- light (up to 1150cc)
- medium (1151-2550cc)
- heavy (+2551cc)

Small coaches
Public coaches/buses
Private coaches

b. Freight transport (22 types)
Light goods vehicles, LGV
Trucks (total weight in kg)
- 2 axles (3501-5000)
- 2 axles (5001-9000)
- 2 axles (9001-13000)
- 2 axles (+13000)
- 3 axles (up to 16000)
- 3 axles (+16000)
- 4 axles (+25000)

Trailer
- light
- 1 axle (3501-10000)
- 2 axles (up to 10000)
- 2 axles (+10000)

3 axles (+10000)
Tractor for semi-trailer (or articulated lorry)
2 axles (up to 3500)
2 axles (3501-13000)
2 axles (+13000)
3 axles (+13000)
Semi-trailer (or articulated lorry)
1 axle (up to 5000)
1 axle (+5000)
2 axles (up to 15000)
2 axles (+15000)
3 axles (+15000)

(BFS, Rev 2000, p. 19; ARE, Fair 2004, p. 19)

In the **Categories account,** the estimated total costs and revenues of the Global account are allocated to the 30 vehicle types (see annex CH-7). The costs are allocated according to a "**costs-by-cause principle"** (UNITE CH, p. 11). This means they are weighted and related explicitly for each vehicle type by objective equivalence factors and according to representative values from experience, which have been calculated by empirical studies (for overview of allocation see annex CH-12, BFS, Rev 2000, p. 23, Tab. 5). Updated and new coefficients were introduced in the year 2000. (BFS, Dumont et al. 2000; BFS, PM 2003, p. 11)

In order to get the most reliable data for these 30 vehicle types, the costs are already differentiated at the time of recording. Even a differentiation between domestic and foreign vehicles is done at the time of recording. However, this distinction is not shown explicitly in the final official road account. (BFS, Rev 2000, p. 20)

The Categories account differs between **current or operating costs I and II, capacity costs** and **weight-related costs I and II**. (UNITE CH, pp. 11)
The cost allocation is based upon extensive experience on the following **8 cost categories** (BFS, Rev 2000, p. 20):

- infrastructure construction
- infrastructure enlargement and improvement
- land purchase
- construction maintenance
- operating maintenance
- administration/personnel
- signalization
- traffic police control

First, the cost share for infrastructure construction and maintenance caused by heavy vehicles is separated. Second, formulae are chosen to allocate these weight-related added costs to the heavy vehicles and the other non-weight-related costs to all vehicles. For this

purpose, the total road expenditures are divided into **6 groups. Each one has its own allocation key:**

1. **Current / operating costs I:** Road expenditures for administration, signalization and traffic police control (= current investment expenditures without chapter 12, see section 2.2). These costs are allocated equally to all vehicle types according to the specific distance travelled (vehicle-kilometers) of the different vehicle types per year.
2. **Current / operating costs II:** Costs for operating maintenance (= current investment expenditures not considered in current / operating costs I, chapter 12, see section 2.2). These costs are allocated equally to all vehicle types according to the specific distance travelled (vehicle-kilometers) of the different vehicle types per year. For the motorcycles, a correcting factor is applied.
3. **Capacity costs** are defined as costs for new infrastructure construction, enlargement and improvement which can not be allocated to the different vehicle types according to the "costs-by-cause principle" and are therefore not weight-related. **80%** of these costs are **considered as being related to the "driveway"** (i.e. the capacity needed to drive upon). They are allocated to the 30 different vehicle types according to the distance travelled (vehicle-kilometers) multiplied by the length of the vehicle. The other **20%** of the capacity costs are independent costs which are **not considered to be related to the "driveway", or to traffic activity**. These costs are allocated according to the distance travelled (vehicle-kilometers). The percentages stem from a hypothesis, formulated in a report of 1985 (in translation): "Faced with the impossibility of identifying precisely at present, with available data, the proportions of costs that are dependent and independent of the capacity for traffic movement (for example space needed for safety barriers, shoulders) a hypothesis was adopted that the dependent costs were 80% and the independent costs 20%".[1] They were confirmed in 2000. (BFS, Dumont et al. 2000; BFS, Rev 2000, pp. 20)
4. **Weight-related costs I consist** of the costs for infrastructure maintenance caused by heavy vehicles (gross weight +3.5 tonnes). They consist of the short-run investment expenditures defined in the Capital account (see 2.2). At present, 45% of these costs are considered to be attributable to heavy vehicles regardless of the road type (national, cantonal and municipal roads). Weight-related costs I are allocated to heavy vehicles according to the ratio of the average Swiss transport performance in vehicle-kilometers multiplied by an **exponential axle-load factor (AFe)**. In 2000, the AFe has been replaced by the new **dynamic or aggressive axle-load factor (AFa)** (BFS, Dumont et al. 2000, see annex CH-8). This factor is calculated for each vehicle type according to the empty weight, the average load and a factor reflecting weight in motion (WIM). The AFa also reflects the technical development of the vehicles. (BFS, Rev 2000, pp. 25) Germany uses a

[1] "Devant l'impossibilité de chiffrer pour l'instant de façon exacte, sur la base des données disponibles, les part des coûts dépendants et indépendants de la capacité resp. du mouvement (barrières de sécurité, aires de repos, ...), une hypothèse a été formulée (coûts dépendent de la capacité = 80%, indépendants = 20%)" (EPFL, Prof. Perret: "Compte routier Suisse - Méthode de répartition des coûts", conclusions/recommandations, pp. 36).

similar approach, whereas Austria has chosen a different method. (Prognos/IWW 2002, p. 22) The percentage was estimated by a study of the accounts of the cantons and municipalities in 1984 (Ermittlung der gewichtsbedingten Mehrkosten in der Strassenrechnung. I. Scazziga, ISETH-ETHZ, November 1984). It was confirmed in 2000. (BFS, Dumont et al. 2000; BFS, Rev 2000, pp. 20)

5. **Weight-related costs II** consist of investments (= long run investment expenditures, see section 2.2) which can be allocated directly to heavy vehicles (gross weight +3.5 tonnes). The proportions for the Capital and the Expenditures account are not the same. In the Expenditures account, the proportion assigned to heavy vehicles is differentiated according to road types. For national roads it is 5.30%, for cantonal roads 4.90% and for municipal roads 7.12% of the investments made for infrastructure construction and land purchase. For the costs of infrastructure improvement, enlargement and maintenance, it is 9.06% for all road types. In the Capital account, the proportion of interest and depreciation of investments assigned to heavy vehicles is 7.05%. Weight-related costs II are allocated to types of heavy vehicles according to their ratio of the average Swiss transport performance in vehicle-kilometers multiplied by a **percentage axle-load factor (AFp)**. The AFp has been changed in 2000 and refers now to the WIM-factor as well. (BFS, Dumont et al. 2000; BFS, Rev 2000, pp. 25, see annex CH-9) The percentages were estimated by a study of the accounts of the cantons and municipalities in 1984 (Ermittlung der gewichtsbedingten Mehrkosten in der Strassenrechnung. I. Scazziga, ISETH-ETHZ, November 1984). They were updated in 2000. (BFS, Dumont et al. 2000; BFS, Rev 2000, pp. 20)
6. **Interests:** The yearly deficits and surpluses are calculated in the Global account, cumulated and bearing the same average interest rate as the investments. The corresponding debits or credits are allocated to all vehicle types according to the ratio of the total costs of the vehicle types. (BFS, Rev 2000, pp. 20; UNITE CH, pp.11)

The updated data for the **Swiss transport performance in vehicle-kilometers** (BFS 2004, by email) used for the cost allocation is shown in annex CH-10.

The annual averages of the vehicle–kilometers per category have a great influence on the results of the Categories account. About 30% of the road expenditures are allocated to the vehicle types according to this indicator. The other expenditures/costs are allocated according to keys which depend on this indicator as well. The same is valid for the revenues. (BFS, Rev 2000, pp. 26)

## 4.2 Revenue allocation

See annex CH-11 (BFS, Rev 2000, p. 24, Tab. 6)

4.3 Formulae

The results of the AASHO-tests, made in the United States of America in the nineteen-fifties, built the basis for the optimal construction characteristics of the roads in Switzerland since 1971. Upon this basis, the **dynamic or aggressive axle-load factors (AFa)** and the **percentage axle-load factors (AFp)** for the different vehicle types have been calculated (BFS, Dumont et al. 2000, pp. 47; see annexes CH-8 and CH-9)

For the calculation of these factors, the formulae and its explanations see annex CH-14 as well as annexes CH-14.2, and CH-14.3.

## 5. Sources of main data, procedures for national compilation

The Swiss Federal Statistical Office does the national compilation and publication of the official Swiss road account on an annual basis with a time lag of two years (for latest publication of Swiss road account 2002, see separate annex CH-13).

The main data for the real current costs and revenues stem from the accounts of the Swiss government for the national roads, the cantons for the cantonal roads and the municipalities for the municipal roads. (BFS, PM 2004, p. 3)

The Federal Statistical Office works together with the cantonal and municipal institutions. In order to be able to do this efficiently, a specific accounting model has been introduced in these institutions in the nineties. Therefore, a systematic recording on all three levels is now possible.

Since the year 1994, the road costs on the cantonal and municipal level are recorded through a full investigation every five years. For the years in between, they are estimated by a representative sample of about 650 objects. (VW 10/92, p. 65)

Other data for the Swiss transport performance are obtained periodically on a national level. These include statistics on Swiss road transport, statistics on transport performance in vehicle-kilometers (PEFA), vehicle stock and statistics on freight transport. (BFS, Rev 2000, p. 26)

The expenditures data come from the accounts of the Federal Office for Highways (ASTRA, for national roads), the cantons for cantonal roads, the municipalities for municipal roads and the corporations for corporation and county roads.
(BFS, PM 2003, p. 8)

In order to get the most reliable data for the 30 different vehicle types, the related costs are already differentiated at the time of recording.

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## ADDRESSES OF KEY EXPERTS

### A. AUSTRIA

Bundesministerium für Verkehr, Innovation und Technologie
Friedrich Schwarz-Herda
Abteilung I/K2
Radetzkystraße 2
A-1030 Wien
Tel: +431 71162 1600
Fax: +431 71162 1699
Email: friedrich.schwarz@bmvit.gv.at

HERRY Consult GmbH
Dr. Max Herry
Dipl.-Ing. Norbert Sedlacek
Argentinierstrasse 21
A-1040 Wien
Tel: +43-1-504 12 58
Fax: +43-1-504 35 36
Email: office@herry.at
http://www.herry.at

### B. GERMANY

Institut fuer Wirtschaftspolitik und Wirtschaftsforschung Universitaet Karlsruhe, IWW
Prof. Dr. Werner Rothengatter
Dr. Claus Doll
Tel: +49 (0)721 608-6042
Fax: +49 (0)721 607376
Email: doll@iww.uni-karlsruhe.de (only until end of January 2005)
New email: c.doll@isi.fraunhofer.de

Bundesministerium fuer Verkehr, Bau- und Wohnungswesen, BMVBW
Dr. jur. Peter Ruidisch
Leiter des Referates A 15
Finanzwirtschaftliche Verkehrsfragen
Frau Susanne Thuermer
Invalidenstrasse 44
D-10115 Berlin
Tel: +49-30-2008-2460

Fax: +49-30-2008-1963
Email: peter.ruidisch@bmvbw.bund.de
Email: susanne.thuermer@bmvbw.bund.de
http://www.bmvbw.bund.de

Deutsches Institut fuer Wirtschaftsforschung, DIW
Dr. Heike Link
Koenigin-Luise-Strasse 5
D-14195 Berlin
Tel: +49-30-89789 Durchwahl 312
Email: hlink@diw.de
http://www.diw.de

ProgTrans AG
Dr. Stefan Rommerskirchen, Geschaeftsfuehrer
Gerbergasse 4
CH-4001 Basel
Tel: +41 61 560 35 00
Fax: +41 61 560 35 01
Email: stefan.rommerskirchen@progtrans.com
http://www.progtrans.com

**C. SWITZERLAND**

INFRAS
Markus Maibach, Mitglied der Geschaeftsleitung
Leiter der Verkehrsabteilung
Forschung und Beratung
Gerechtigkeitsgasse 20, Postfach
CH-8039 Zuerich
Tel: +41 1 205 95 08
Fax: +41 1 205 95 99
Email: markus.maibach@infras.ch
http://www.infras.ch

Bundesamt fuer Statistik, BFS
Martin Schweizer
Sektion Verkehr
Espace de l'Europe 10
CH-2010 Neuchatel
Tel : +41 32 713 68 93

Email: martin.schweizer@bfs.admin.ch
http://www.statistik.admin.ch

Schweizer privat: Tel +41 32 338 26 85 Natel +41 76 330 26 85

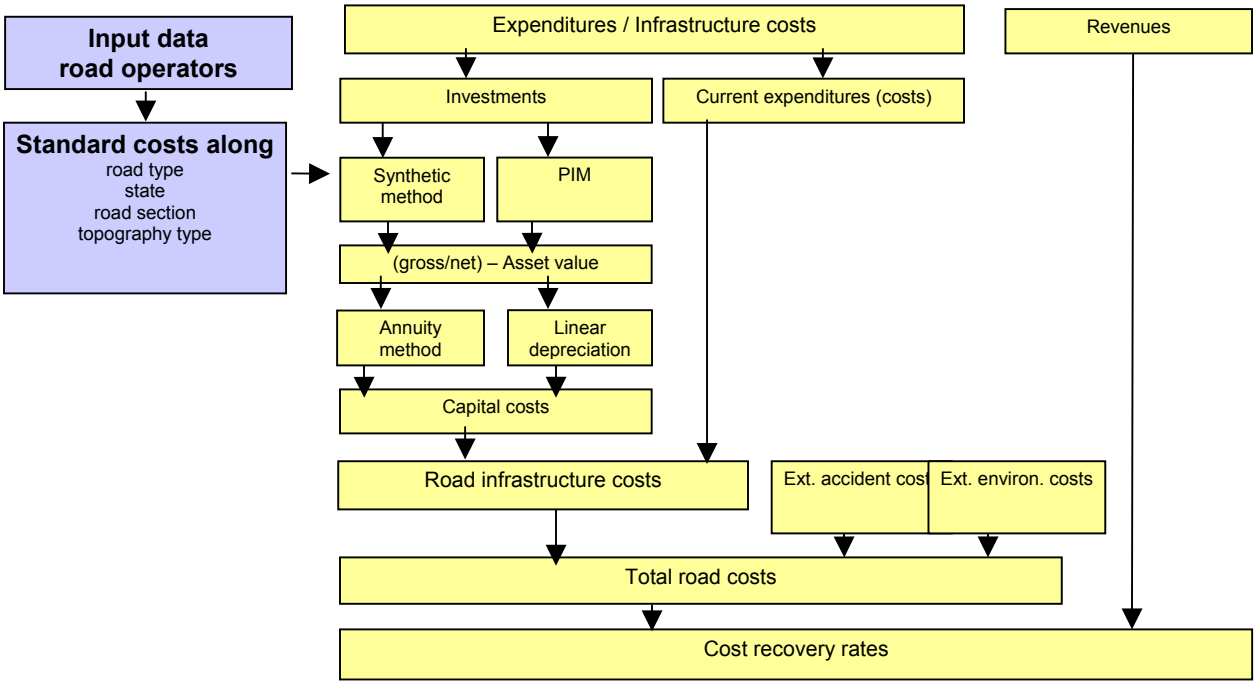
Bundesamt fuer Raumentwicklung, ARE
Bundeshaus Nord
Kochergasse 10
CH-3003 Bern
Christian Albrecht, Head of Transport Policy
Email: christian.albrecht@are.admin.ch
Ueli Balmer, Specialist of HVF in CH, Email: ueli.balmer@are.admin.ch
Nathalie Carron, Email: nathalie.carron@are.admin.ch
http://www.are.admin.ch

FBB, March 24, 2005

**ANNEXES**

**Annex A-1** (WKR 2003, p. 45, Abb. 13)

**Scheme of road cost accounting process in Austria 2000**



**Annex A-2** (WKR 2003, p. 100, Tab. 46)

**Allocation key for capital costs**

| *Vehicle type* | *Motorways, expressways* | *Federal primaries* |
|---|---|---|
| Passenger cars (PC), PC + trailers, Light goods vehicles | 45% | 50% |
| Coaches | 2% | 7% |
| HGV (3.5 t to 7.5 t rtw) | 2% | 2% |
| HGV (7.5 t to 12 t rtw) | 2% | 2% |
| HGV (12 t to 18 t rtw) | 4% | 5% |
| HGV (18 t to 28 t rtw) | 3% | 5% |
| HGV (from 28 t rtw upwards) | 42% | 29% |
| ***Total*** | **100%** | **100%** |

(HGV: heavy goods vehicles; t rtw: tonnes registered total weight)

**Annex A-3** (WKR 2003, p. 101, Tab. 47)

**Allocation key for current operating costs**

| *Vehicle type* | *Motorways, expressways* | *Federal primaries* |
|---|---|---|
| Passenger cars (PC), PC + trailers, Light goods vehicles | 33% | 44% |
| Coaches | 3% | 8% |
| HGV (3.5 t to 7.5 t rtw) | 1% | 2% |
| HGV (7.5 t to 12 t rtw) | 1% | 2% |
| HGV (12 t to 18 t rtw) | 3% | 5% |
| HGV (18 t to 28 t rtw) | 3% | 6% |
| HGV (from 28 t rtw upwards) | 56% | 33% |
| ***Total*** | **100%** | **100%** |

(HGV: heavy goods vehicles; t rtw: tonnes registered total weight)

**Annex A-4** (WKR 2003, p. 109, Tab. 50, capital costs; p. 112, Tab. 53, current costs)

**Capital costs Austrian roads 2000, main option "time value"** (in million Euro)

| | **Capital costs** | **Vkm travelled** |
|---|---|---|
| Motorways | 635 | 1,613 |
| Expressways | 93 | 296 |
| Federal primaries | 704 | 9,960 |
| All federal roads | 1,432 | 11,869 |
| States and municipal roads | 1,585 | 94,472 |
| **All roads** | **3,018** | **106,341** |

(vkm: vehicle-kilometers)

**Total current operating costs Austrian roads 2000** (in million Euro to prices in 2000)

| **Motorways** | **Expressways** | **Federal primaries** | **States/municipal roads** | **All roads** |
|---|---|---|---|---|
| 270 | 36 | 275 | 1,213 | 1,794 |

**Annex A-5** (WKR 2003, p. 122, Tab. 64)

**Categorized capital costs 2000, main option "time value"** (in million Euro)

| | **Motorways, expressways** | **Federal primaries** | **States, municipal roads** | **All roads** |
|---|---|---|---|---|
| Passenger cars (PC), PC + trailers, Light goods vehicles | 326 | 352 | 792 | 1,470 |
| Coaches | 17 | 50 | 113 | 180 |
| HGV (3.5 t to 7.5 t rtw) | 13 | 16 | 36 | 65 |
| HGV (7.5 t to 12 t rtw) | 11 | 12 | 27 | 51 |
| HGV (12 t to 18 t rtw) | 29 | 33 | 73 | 135 |
| HGV (18 t to 28 t rtw) | 24 | 36 | 82 | 142 |
| HGV (28 t rtw upwards) | 308 | 205 | 462 | 975 |
| All HGV | 386 | 302 | 680 | 1,368 |
| ***Total*** | ***728*** | ***704*** | ***1,585*** | ***3,018*** |

(HGV: heavy goods vehicles; t rtw: tonnes registered total weight)

**Annex A-6** (WKR 2003, p. 124, Tab. 66)

**Categorized current operating costs 2000** (in million Euro)

| | **Motorways, expressways** | **Federal primaries** | **States, municipal roads** | **All roads** |
|---|---|---|---|---|
| Passenger cars (PC), PC + trailers, Light goods vehicles | 101 | 120 | 528 | 749 |
| Coaches | 8 | 22 | 98 | 128 |
| HGV (3.5 t to 7.5 t rtw) | 4 | 7 | 29 | 39 |
| HGV (7.5 t to 12 t rtw) | 3 | 5 | 22 | 30 |
| HGV (12 t to 18 t rtw) | 9 | 14 | 61 | 84 |
| HGV (18 t to 28 t rtw) | 10 | 16 | 72 | 98 |
| HGV (28 t rtw upwards) | 171 | 91 | 404 | 667 |
| All HGV | 197 | 133 | 587 | 917 |
| ***Total*** | ***306*** | ***275*** | ***1,213*** | ***1,794*** |

(HGV: heavy goods vehicles; t rtw: tonnes registered total weight)

**Annex A-7** (WKR 2003, p. 126, Tab. 68)

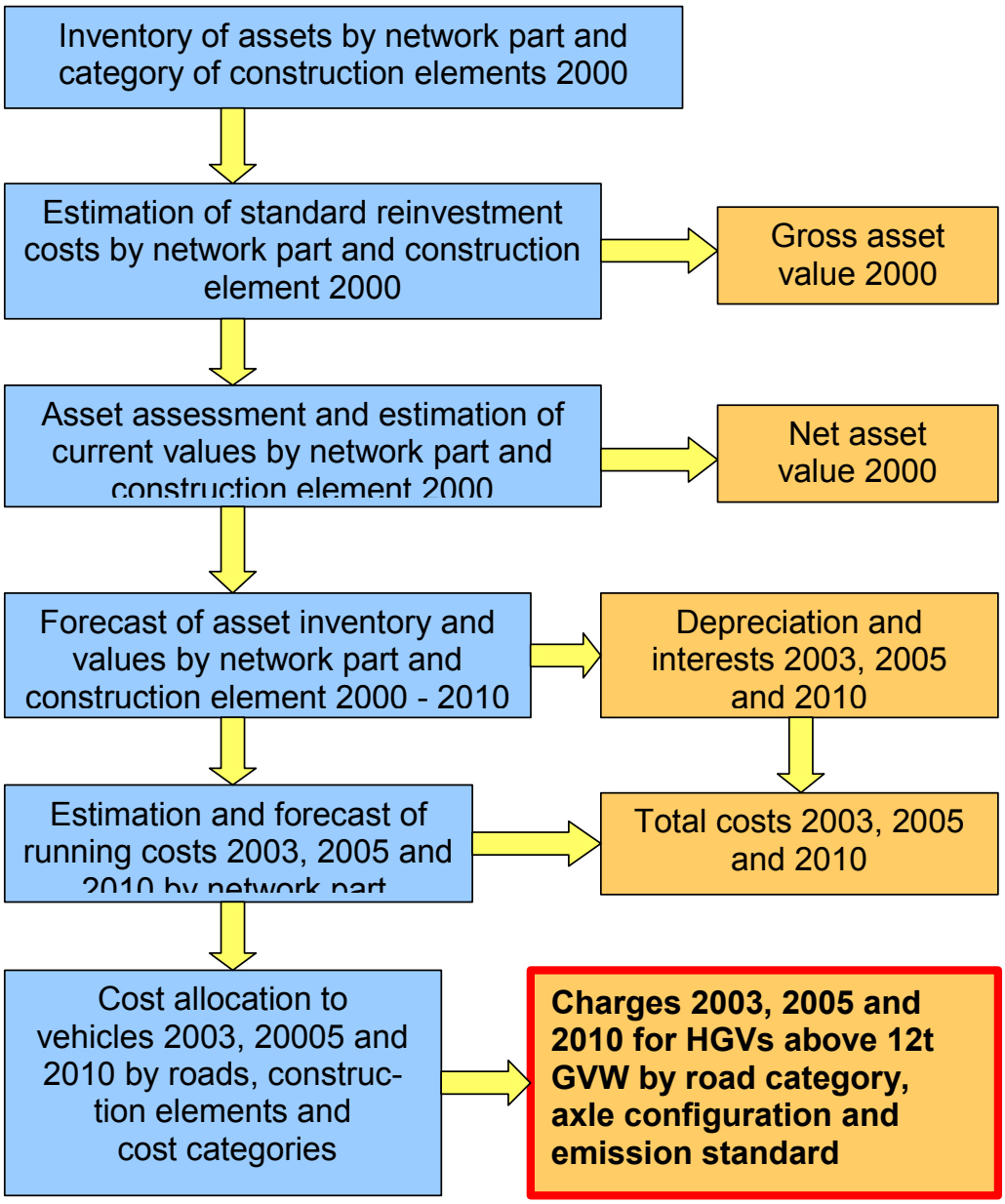
**Categorized revenues 2000** (in million Euro)

| | **Motorways, expressways** | **Federal primaries** | **States, municipal roads** | **All roads** |
|---|---|---|---|---|
| Passenger cars (PC), PC + trailers, Light goods vehicles | 1,299 | 1,280 | 985 | 3,564 |
| Coaches | 20 | 20 | 13 | 53 |
| HGV (3.5 t to 7.5 t rtw) | 26 | 19 | 14 | 59 |
| HGV (7.5 t to 12 t rtw) | 22 | 18 | 13 | 53 |
| HGV (12 t to 18 t rtw) | 47 | 43 | 32 | 121 |
| HGV (18 t to 28 t rtw) | 35 | 30 | 19 | 83 |
| HGV (28 t rtw upwards) | 387 | 96 | 88 | 571 |
| All HGV | 517 | 205 | 165 | 887 |
| ***Total*** | ***1,837*** | ***1,505*** | ***1,163*** | ***4,505*** |

(HGV: heavy goods vehicles; t rtw: tonnes registered total weight)

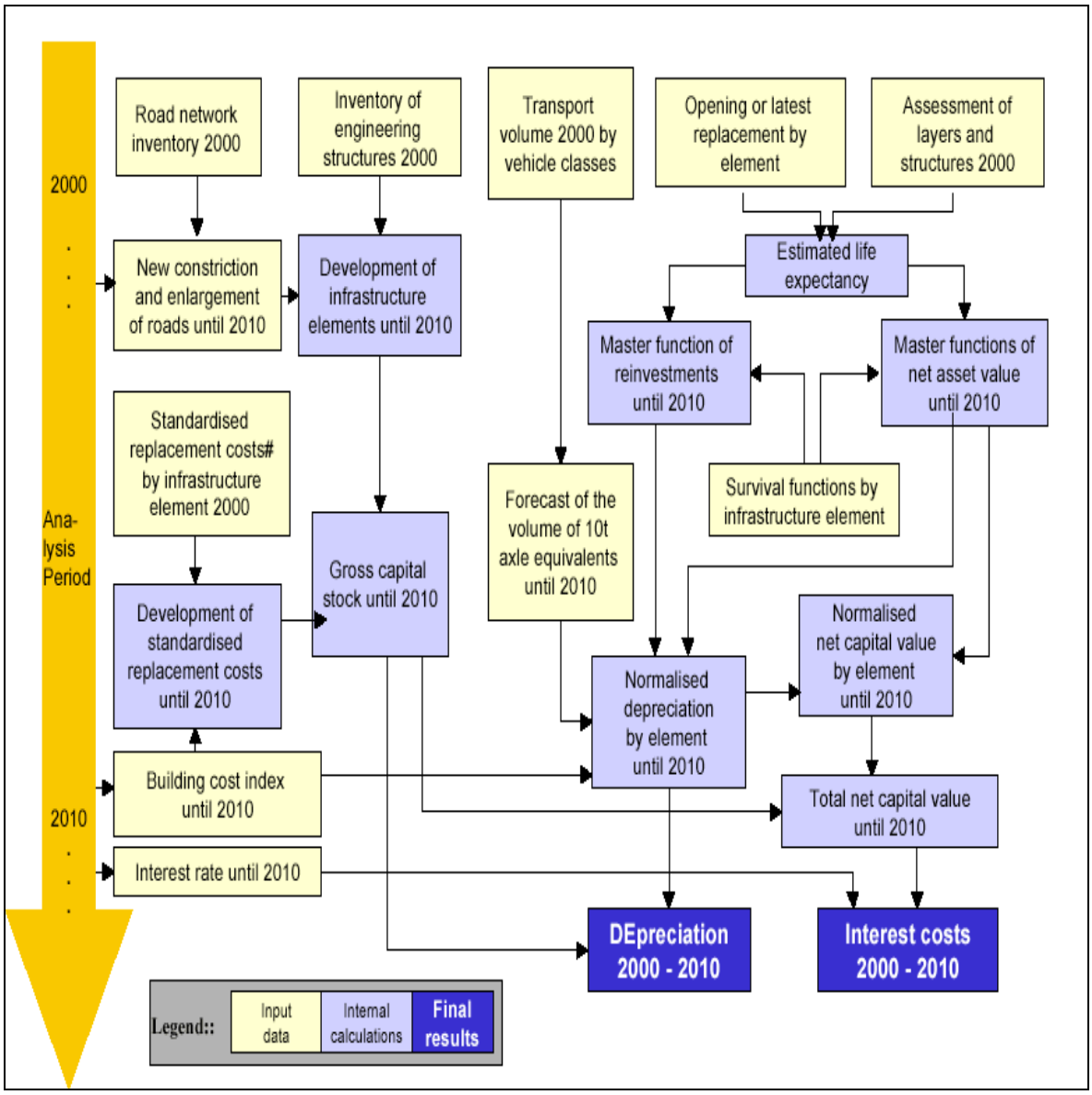
**Annex D-1** (Prognos/IWW 2002, p. Z-3, Abbildung Z-1)

**New German road cost account: overview of accounting process**



**Annex D-2** (Prognos/IWW 2002, p. 82, Abbildung 4-1)

**Algorithm of capital cost estimation, schematic overview**



**Annex D-3** (Prognos/IWW 2002, p. 69, Abbildung 3-12)

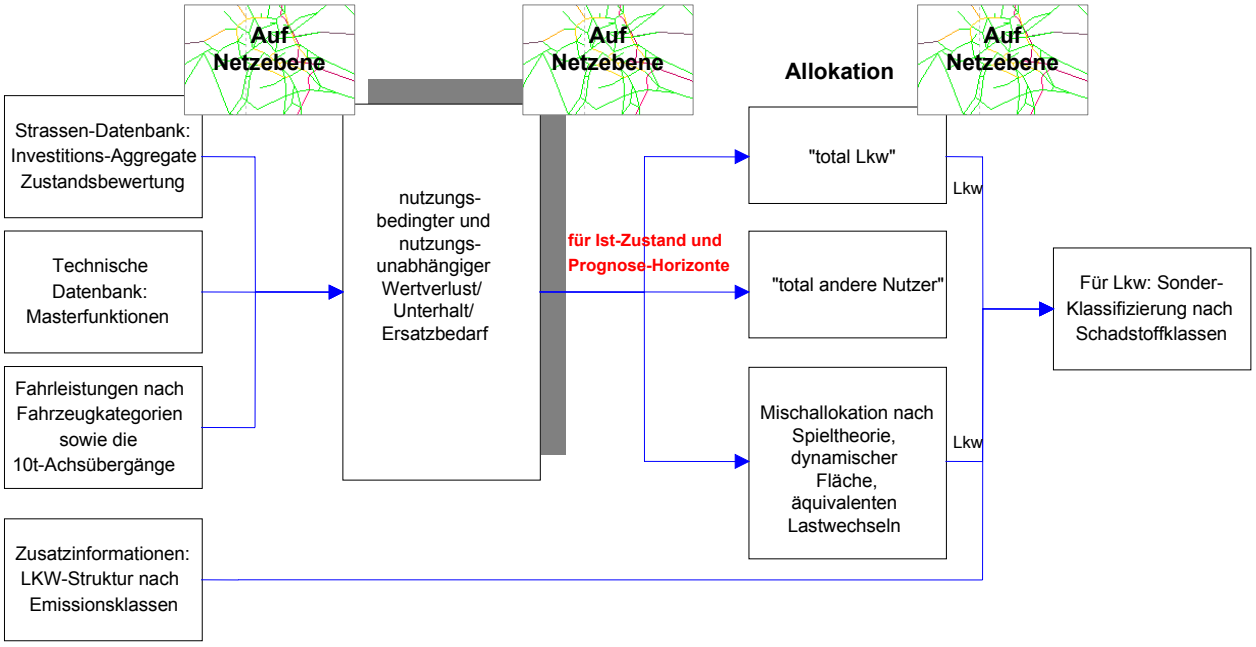
**Scheme of bottom up accounting process with cost allocation**
(on the road network)

input data

wear and tear, maintenance, reinvestment

for actual situation and forecast

allocation




"mixed allocation" by
- game theory
- dynamic area
- equivalence factors

**Annex D-4** (Prognos/IWW 2002, p. 129, Tabelle 5-4)

**Old and new equivalence factors**

| **Vehicle category** | **old equivalence factors (1969)** | **new equivalence factors** |
|---|---|---|
| Passenger cars | 1.0 | 1.0 |
| Coaches | 3.0 | 2.5 |
| Motorcycles | 0.5 | 0.5 |
| Trucks | | |
| 3,5 t | 1.7 | 1.2 |
| 3,5 - 12 t | 2.2 – 2.7 | 1.5 |
| 12 - 18 t | 4.3 | 2.5 |
| 18 - 28 t | 5.8 | 3.5 |
| 28 - 33 t | 5.8 | 4.0 |
| 33 t and more | 5.8 | 4.5 |
| Articulated trucks | 6.0 | 4.5 |
| Other road vehicles | 6.0 | 2.0 |

**Annex D-5** (Prognos/IWW 2002, p. 128, Tab. 5-3)

*Tab. 5-3: Allocation scheme: allocation of construction element costs to allocation principles*

| Allocation principle / Construction elements | | Costs allocated proportionally (according to vkm travelled | System specific costs (Passenger cars) | System specific costs (trucks ≥ 12 t) | Capacity-related costs (equivalence factors) | Weight-related costs (AASHO) |
|---|---|---|---|---|---|---|
| Land purchase | | | | | 100 | |
| Earthwork/ drainage | New | | | | 100 | |
| | Maintenance | | | | 100 | |
| Base course | New | | | 73 | 27 | |
| | Maintenance | | | | | 100 |
| Binder course | New | | | 100 | | |
| | Maintenance | | | | | 100 |
| Surface course | New | | | | 100 | |
| | Maintenance | | | | | 100 |
| Tunnels | New | 45 | | 5 | 50 | |
| | Maintenance | 80 | | 20 | | |
| Bridges | New | | | 15 | 85 | |
| | Maintenance | | | 15 | 85 | |
| Equipment | New | 33 | | | 67 | |
| | Maintenance | 33 | | | 67 | |
| Intersections/exits | New | 15 | 20 | 15 | 50 | |
| | Maintenance | 15 | | 10 | 40 | 35 |
| Other engineering work | New | 33 | | | 67 | |
| | Maintenance | 33 | | | 67 | |
| Administration, police | | 30 | | | 70 | |
| Operating maintenance | | 35 | | 15 | 50 | |

**Annex D-6** (Prognos/IWW 2002, pp. 144, Tab. 6-1, 6-4, 6-8, 6-9)

**Results German road cost account 2003: Total road costs and cost allocation to construction elements and vehicle categories 2003**

(Prognos/IWW 2002, pp. 144)

**1. Federal motorways**

The **gross asset value (GAV)** of the federal motorways in 2003 has been estimated to be 123.8 billion Euro (€). The **net asset value (NAV)** has been estimated to be 75.8 billion €, which is 61 % of the GAV (see Tab. 6-1 below).

The **total road costs** for the federal motorways are 7.51 billion Euro. Out of these, 5.34 billion € are capital costs and 2.17 billion € current operating costs. The depreciation costs are 2.31 billion € and the interest costs are 3.03 billion € (see Tab. 6-1 below).

Tab. 6-8 (below) shows the **cost allocation to construction elements and vehicle categories** for the federal motorways in 2003.

**2. Federal primaries (roads)**

The **gross asset value (GAV)** of the federal primaries in 2003 has been estimated to be 126.55 billion Euro (€). The **net asset value (NAV)** has been estimated to be 72.37 billion €, which is 57 % of the GAV (see Tab. 6-4 below).

The **total road costs** for the federal primaries are 7.18 billion Euro. Out of these, 5.33 billion € are capital costs and 1.85 billion € current operating costs. The depreciation costs are 2.44 billion € and the interest costs are 2.90 billion € (see Tab. 6-4 below).

Tab. 6-9 (below) shows the **cost allocation to construction elements and vehicle categories** for the federal primaries in 2003.

*Tab. 6-1: Total road costs federal motorways 2003 (billion Euro)* (Prognos/IWW 2002, p. 146)

| Cost elements | Asset values of new and replacement investments | | | Road costs | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Capital costs of new and replacement investments | | | Construction maintenance and operating costs | | | Total road costs |
| | Gross asset value | Net asset value | Age structure | Depreciation | Interests | Total capital costs | Capitalized maintenance investments | Current costs | Maintenance and current costs | |
| Sections | | | | | | | | | | |
| Land | 11.87 | 11.87 | 100% | | 0.47 | 0.47 | | | | 0.47 |
| Earthwork | 24.43 | 14.05 | 58% | 0.26 | 0.56 | 0.83 | | | | 0.83 |
| Base course | 11.07 | 6.32 | 57% | 0.16 | 0.25 | 0.41 | | | | 0.41 |
| Surface layers 1) | 7.63 | 4.05 | 53% | 0.41 | 0.16 | 0.57 | | | | 0.57 |
| Other elements | | | | | | | | | | |
| Equipment 2) | 16.69 | 8.74 | 52% | 0.85 | 0.35 | 1.20 | | | | 1.20 |
| Intersections 3) | 14.67 | 10.01 | 68% | 0.29 | 0.40 | 0.69 | | | | 0.69 |
| Tunnels | 4.39 | 3.61 | 82% | 0.01 | 0.14 | 0.15 | 0.04 | | 0.04 | 0.19 |
| Bridges | 32.57 | 16.89 | 52% | 0.31 | 0.68 | 0.99 | 0.21 | | 0.21 | 1.20 |
| Other engineering work 4) | 0.48 | 0.26 | 54% | 0.01 | 0.01 | 0.02 | | | | 0.02 |
| Operation | | | | | | | | | | |
| Operating maintenance 5) | | | | | | | | 0.45 | 0.45 | 0.45 |
| Administration and police 6) | | | | | | | | 0.91 | 0.91 | 0.91 |
| Charging system | | | | | | | | 0.56 | 0.56 | 0.56 |
| Total | 123.80 | 75.80 | 61% | 2.31 | 3.03 | 5.34 | 0.25 | 1.92 | 2.17 | 7.51 |

1) surface and binder course - 2) includes noise protection - 3) additional land for intersections and exits - 4) passages, reinforcement work and traffic signal bridges - 5) green care, winter service und traffic safety - 6) expenditures of the states

*Tab. 6-4: Total road costs federal primaries (roads) 2003 (billion Euro)* (Prognos/IWW 2002, p. 149)

| Cost elements | Asset values of new and replacement investments | | | Road costs | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Capital costs of new and replacement investments | | | Construction maintenance and operating costs | | | Total road costs |
| | Gross asset value | Net asset value | Age structure | Depreciation | Interests | Total capital costs | Capitalized maintenance investments | Current costs | Maintenance and current costs | |
| Sections | | | | | | | | | | |
| Land | 16.82 | 16.82 | 100% | | 0.67 | 0.67 | | | | 0.67 |
| Earthwork | 40.18 | 18.44 | 46% | 0.43 | 0.74 | 1.17 | | | | 1.17 |
| Base course | 18.69 | 9.73 | 52% | 0.28 | 0.39 | 0.67 | | | | 0.67 |
| Surface layers 1) | 9.63 | 4.46 | 46% | 0.56 | 0.18 | 0.74 | | | | 0.74 |
| Other elements | | | | | | | | | | |
| Equipment 2) | 18.86 | 9.65 | 51% | 0.96 | 0.39 | 1.35 | | | | 1.35 |
| Intersections 3) | | | | | | | | | | |
| Tunnels | 2.09 | 1.77 | 85% | 0.01 | 0.07 | 0.08 | 0.02 | | 0.02 | 0.10 |
| Bridges | 19.84 | 11.29 | 57% | 0.20 | 0.45 | 0.65 | 0.16 | | 0.16 | 0.80 |
| Other engineering work 4) | 0.44 | 0.21 | 48% | 0.01 | 0.01 | 0.02 | | | | 0.02 |
| Operation | | | | | | | | | | |
| Operating maintenance 5) | | | | | | | | 0.55 | 0.55 | 0.55 |
| Administration and police 6) | | | | | | | | 1.11 | 1.11 | 1.11 |
| Charging system | | | | | | | | | | |
| Total | 126.55 | 72.37 | 57% | 2.44 | 2.90 | 5.33 | 0.18 | 1.66 | 1.85 | 7.18 |

1) surface and binder course - 2) includes noise protection - 3) additional land for intersections and exits - 4) passages, reinforcement work and traffic signal bridges - 5) green care, winter service und traffic safety - 6) expenditures of the states

*Tab. 6-8: Cost allocation to construction elements and vehicle categories 2003, federal motorways* (Prognos/IWW 2002, p. 156)

| Vehicle category | Costs along construction elements | | | | | | | | Total costs (billion €) | Billion vkm | Costs (Euro/ vkm) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Land | Earthwork | Super-structure | Engin. work** | Equipment | Intersec-tions/exits | Administr./ Operation | Charging system | | | |
| | Road costs federal motorways 2003 in prices of 2003 (billion Euro) | | | | | | | | | | |
| Passenger cars | 0.28 | 0.48 | 0.07 | 0.73 | 0.79 | 0.34 | 0.85 | 0.00 | 3.54 | 164.7 | 0.02 |
| Light duty vehicles | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.00 | 0.01 | 0.00 | 0.03 | 2.1 | 0.01 |
| Coaches | 0.01 | 0.01 | 0.07 | 0.01 | 0.01 | 0.02 | 0.01 | 0.00 | 0.14 | 1.4 | 0.10 |
| Trucks - 12 t | 0.03 | 0.05 | 0.01 | 0.07 | 0.07 | 0.03 | 0.07 | 0.00 | 0.32 | 1.1 | 0.03 |
| Trucks+SZ* 12 t upwards | 0.16 | 0.27 | 0.83 | 0.57 | 0.31 | 0.30 | 0.40 | 0.56 | 3.40 | 22.7 | 0.15 |
| Other trucks | 0.01 | 0.01 | 0.00 | 0.02 | 0.02 | 0.01 | 0.02 | 0.00 | 0.08 | 2.1 | 0.04 |
| All trucks | 0.47 | 0.83 | 0.99 | 1.41 | 1.20 | 0.69 | 1.36 | 0.56 | 7.51 | 205.2 | 0.03 |

*SZ=articulated trucks; **Bridges, tunnels, other engineering work

(vkm: vehicle-kilometers)

*Tab. 6-9: Cost allocation to construction elements and vehicle categories 2003, federal primaries (roads)* (Prognos/IWW 2002, p. 157)

| Vehicle category | Costs along costruction elements | | | | | | Total costs (billion €) | Billion vkm | Costs (Euro/ vkm) |
|---|---|---|---|---|---|---|---|---|---|
| | Land | Earthwork | Super-structure | Engin. work ** | Equipment | Administr./ Operation | | | |
| | Road costs federal roads (primaries) 2003 in prices of 2003 (billion Euro) | | | | | | | | |
| Passenger cars | 0.46 | 0.80 | 0.11 | 0.55 | 0.98 | 1.15 | 4.05 | 99.9 | 0.04 |
| Light duty vehicles | 0.01 | 0.01 | 0.00 | 0.01 | 0.02 | 0.03 | 0.08 | 3.4 | 0.02 |
| Coaches | 0.01 | 0.02 | 0.18 | 0.01 | 0.02 | 0.02 | 0.26 | 1.0 | 0.27 |
| Trucks - 12 t | 0.04 | 0.07 | 0.02 | 0.05 | 0.08 | 0.10 | 0.36 | 7.0 | 0.05 |
| Trucks+SZ* 12 t upwards | 0.14 | 0.24 | 1.08 | 0.28 | 0.21 | 0.33 | 2.28 | 7.6 | 0.30 |
| Other trucks | 0.02 | 0.03 | 0.01 | 0.02 | 0.03 | 0.04 | 0.14 | 1.9 | 0.07 |
| All trucks | 0.67 | 1.17 | 1.40 | 0.92 | 1.35 | 1.66 | 7.18 | 120.8 | 0.06 |

*SZ=articulated trucks; **Bridges, tunnels, other engineering work

(vkm: vehicle-kilometers)

**Annex CH-1** (ARGE Herry/Infras/Prognos, Figur 3-1, 1994, p. 30)

**Swiss road account: overview (see next page)**

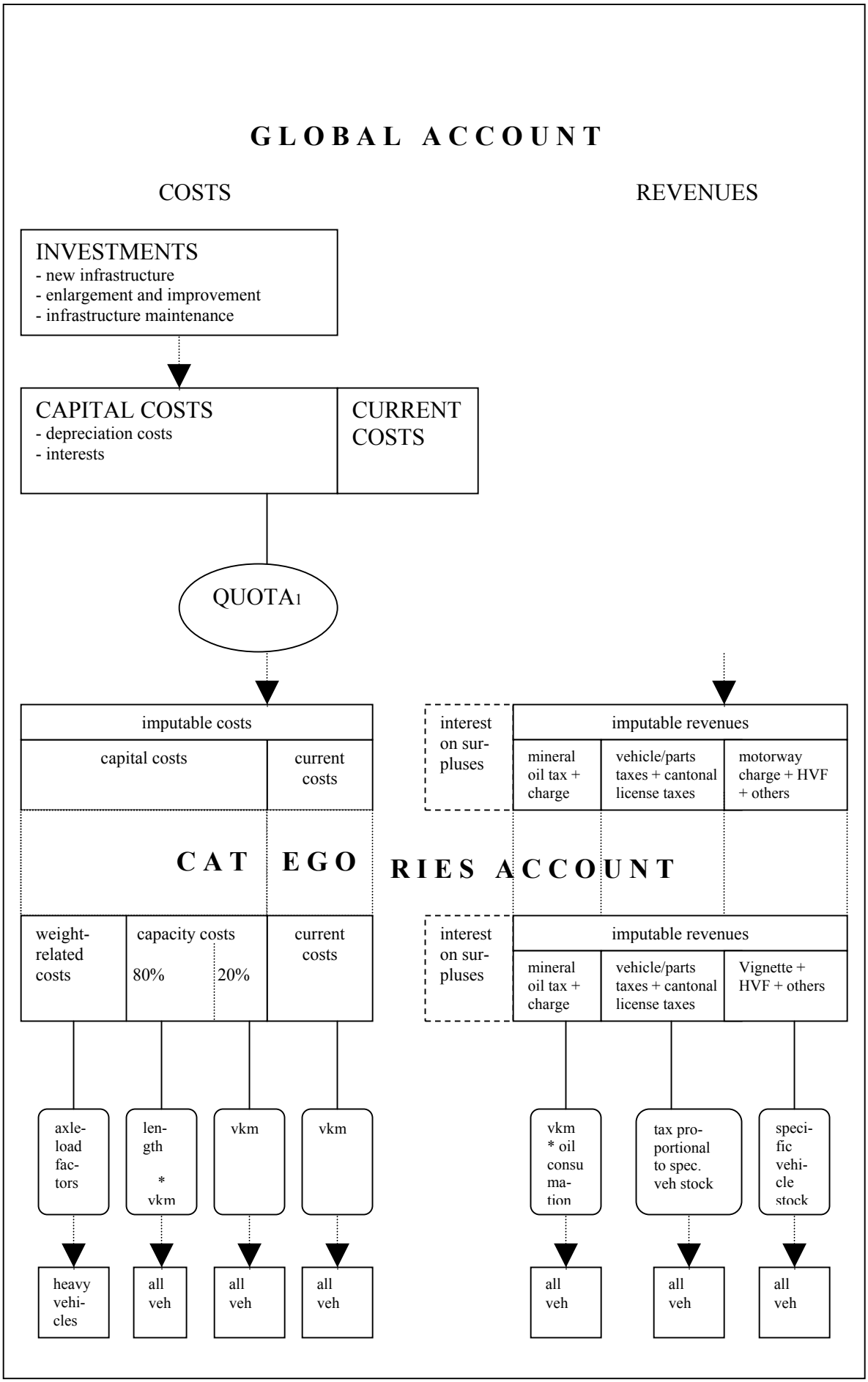
The Swiss road account differs between a **Global account** and a **Categories account**. Both are full cost accounts.

The following figure shows the different working steps of the Swiss road account in an overview.

1 Quota: Infrastructure expenditures for motorized traffic are decided by quotas in Switzerland. The quotas for the expenditures taken into account for the three different road categories are the following:

- for national roads: 100%
- for cantonal roads: 90 %
- for municipal roads: 70%

(vkm: vehicle-kilometers)


GLOBAL ACCOUNT
COSTS
REVENUES
INVESTMENTS
- new infrastructure
- enlargement and improvement
- infrastructure maintenance
CAPITAL COSTS
- depreciation costs
- interests
CURRENT COSTS
QUOTA1
imputable costs
capital costs
current costs
interest on sur-pluses
imputable revenues
mineral oil tax + charge
vehicle/parts taxes + cantonal license taxes
motorway charge + HVF + others
CAT EGO RIES ACCOUNT
weight-related costs
capacity costs
80%
20%
current costs
interest on sur-pluses
imputable revenues
mineral oil tax + charge
vehicle/parts taxes + cantonal license taxes
Vignette + HVF + others
axle-load fac-tors
len-gth * vkm
vkm
vkm
vkm * oil consu ma-tion
tax pro-portional to spec. veh stock
speci-fic vehi-cle stock
heavy vehi-cles
all veh
all veh
all veh
all veh
all veh
all veh

**Annex CH-2** (BFS, PM 2003, p. 10, Tab. 5)

## Global account (1990-2001, in million Swiss francs)

Tableau 5: Compte global de 1990 à 2001, en millions de francs

| Années | Recettes à porter en compte | Compte de capital | | | | Compte de dépenses | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Coûts imputables et intérêts | dont intérêt sur les excédents cumulés | Degré d'équilibre financier en % | Excédent ou insuffisance de la couverture[1] | Dépenses imputables et intérêts | dont intérêt sur les excédents cumulés | Degré de couverture en % | Excédent ou insuffisance de la couverture[1] |
| 1990 | 5 023 | 5 096 | - 41 | 99 | -73 | 6 104 | +1 371 | 82 | -1 081 |
| 1992 | 5 312 | 6 134 | - 3 | 87 | -822 | 7 081 | +1 807 | 75 | -1 769 |
| 1993 | 6 169 | 6 186 | - 1 | 100 | -17 | 7 141 | +1 794 | 86 | - 972 |
| 1994 | 6 521 | 6 353 | - 10 | 103 | + 168 | 7 077 | +1 822 | 92 | - 556 |
| 1995 | 6 412 | 6 441 | - 8 | 100 | -29 | 6 866 | +1 845 | 93 | - 454 |
| 1996 | 6 616 | 6 545 | - 12 | 101 | + 71 | 6 736 | +1 818 | 98 | - 120 |
| 1997 | 6 659 | 6 591 | - 14 | 101 | + 68 | 6 723 | +1 788 | 99 | -64 |
| 1998 | 6 983 | 6 599 | - 32 | 106 | + 384 | 6 681 | +1 674 | 105 | + 302 |
| 1999 | 7 228 | 6 752 | - 51 | 107 | + 476 | 6 991 | +1 596 | 103 | + 237 |
| 2000 | 7 608 | 6 680 | - 88 | 114 | + 928 | 6 861 | +1 498 | 111 | + 747 |
| 2001[2] | 7 624 | 6 775 | - 121 | 113 | + 849 | 6 845 | +1 432 | 111 | + 779 |

[1] Insuffisance de la couverture = - / Excédent de couverture = +
[2] Résultats provisoires

**Annex CH-3** (BFS, PM 2003, p. 11, Tab. 6)

**The costs of the Capital account (2001 in 1000 Swiss francs)**

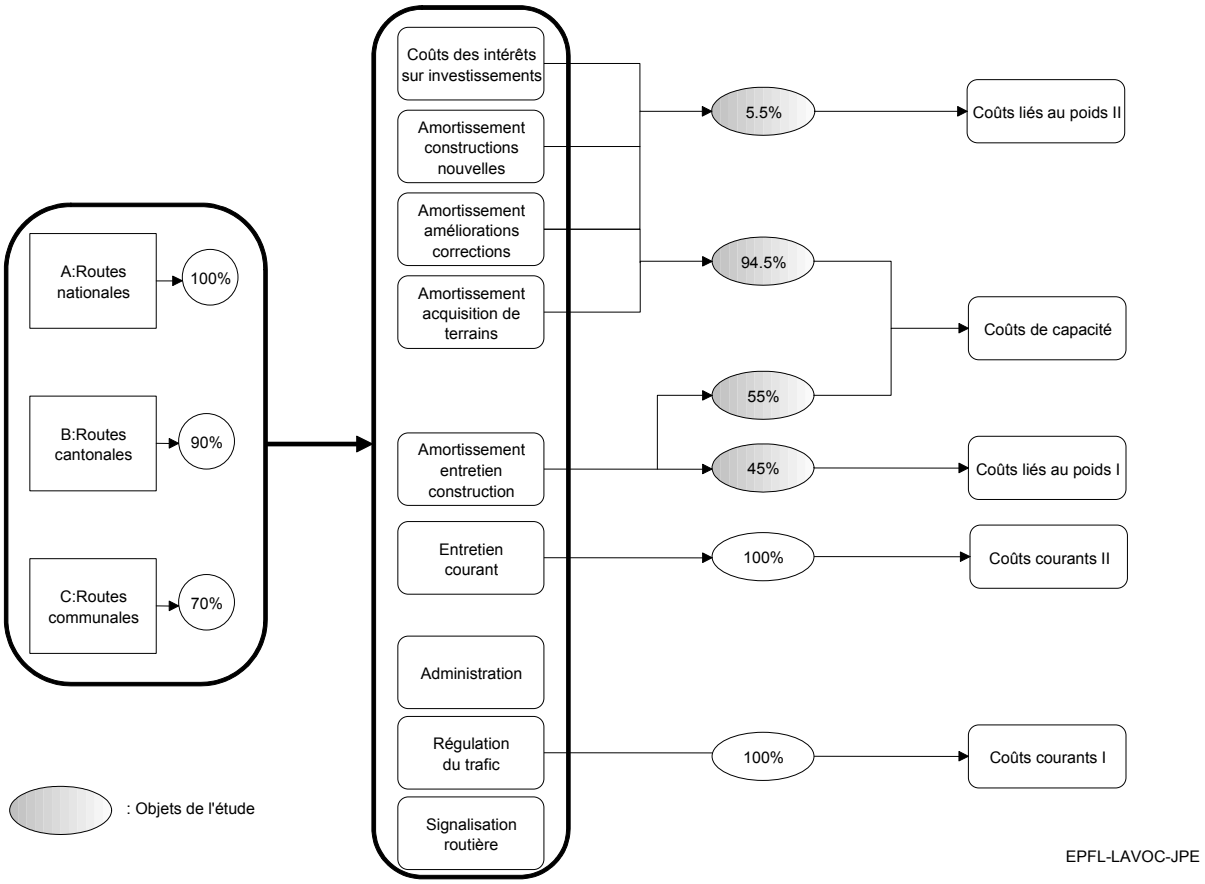
Tableau 6: Les coûts du compte de capital en 2001, en milliers de francs[1]

| Centre de frais | Routes nationales | Routes cantonales | Routes communales | Total |
|---|---|---|---|---|
| Valeur d'établissement des routes en 1919 | | 59 000 | 61 000 | 120 000 |
| Acquisitions de terrain cumulées | 4 136 590 | 2 272 856 | 1 926 944 | 8 336 390 |
| Valeur résiduelle des constructions nouvelles | 26 731 794 | 12 454 098 | 9 478 991 | 48 664 883 |
| Valeur résiduelle de l'entretien de construction | 2 130 894 | 1 257 904 | 1 420 648 | 4 809 446 |
| Valeur résiduelle totale | 32 999 278 | 16 043 858 | 12 887 583 | 61 930 719 |
| Intérêt résiduel : 4,3% | 1 418 969 | 689 886 | 554 166 | 2 663 021 |
| Amortissement des constructions nouvelles | 1 123 218 | 496 482 | 432 550 | 2 052 250 |
| Amortissement de l'entretien de construction | 292 588 | 193 410 | 224 245 | 710 243 |
| Coûts de capital (intérêts et amortissements) | 2 834 775 | 1 379 778 | 1 210 961 | 5 425 514 |
| Coûts d'exploitation | 327 652 | 933 806 | 1 148 533 | 2 409 991 |
| Coûts totaux | 3 162 427 | 2 313 584 | 2 359 494 | 7 835 505 |
| Quotité | 100% | 90% | 70% | - |
| Coûts imputables | 3 162 427 | 2 082 226 | 1 651 646 | 6 896 298 |

[1] Résultats provisoires
[2] Avant le calcul de l'intérêt sur les excédents et insuffisances cumulés

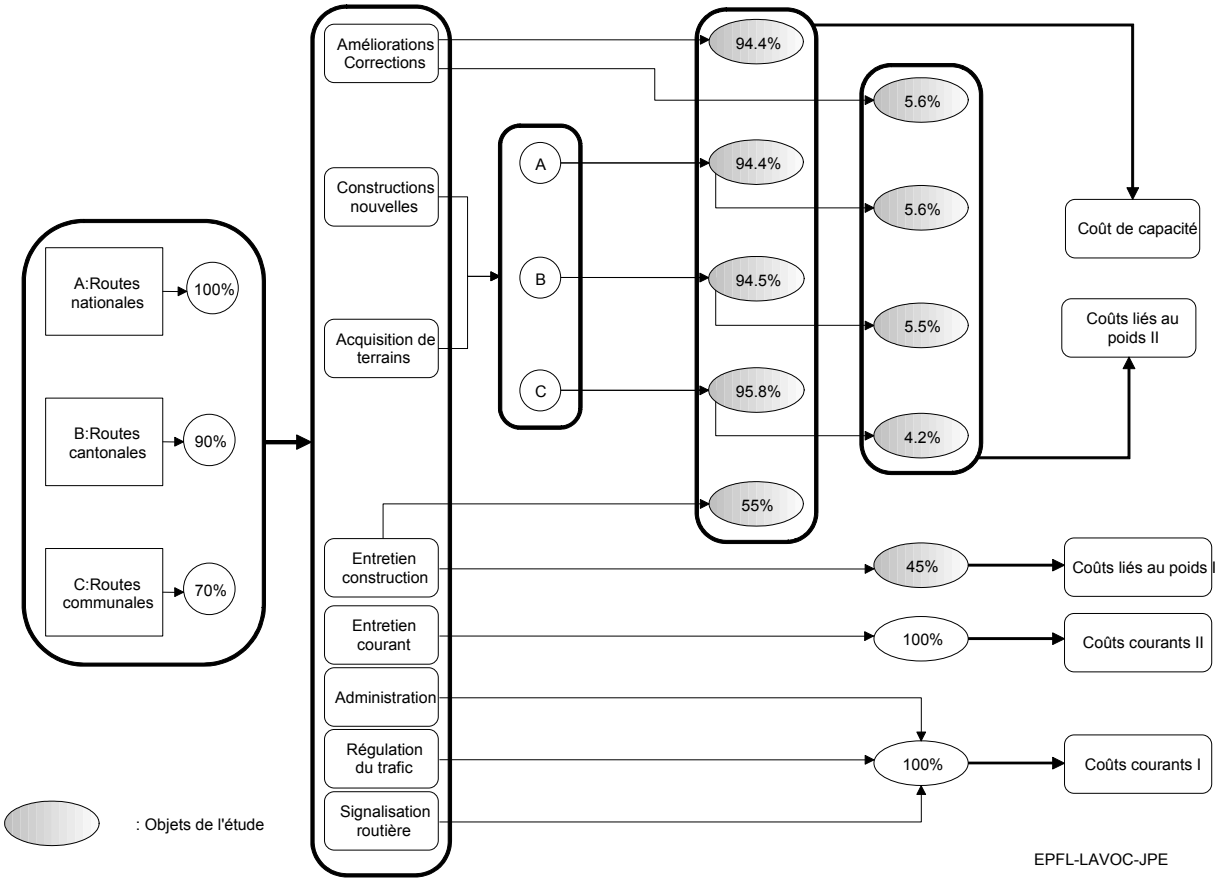
**Annex CH-4** (BFS, Dumont et al. 2000, Annexes, p. 61 sur LXIX)

## Capital account : Organigramme du compte de capital



**Annex CH-5** (BFS, Dumont et al. 2000, Annexes, p. 60 sur LXIX)

## Expenditures account : Organigramme du compte de dépenses



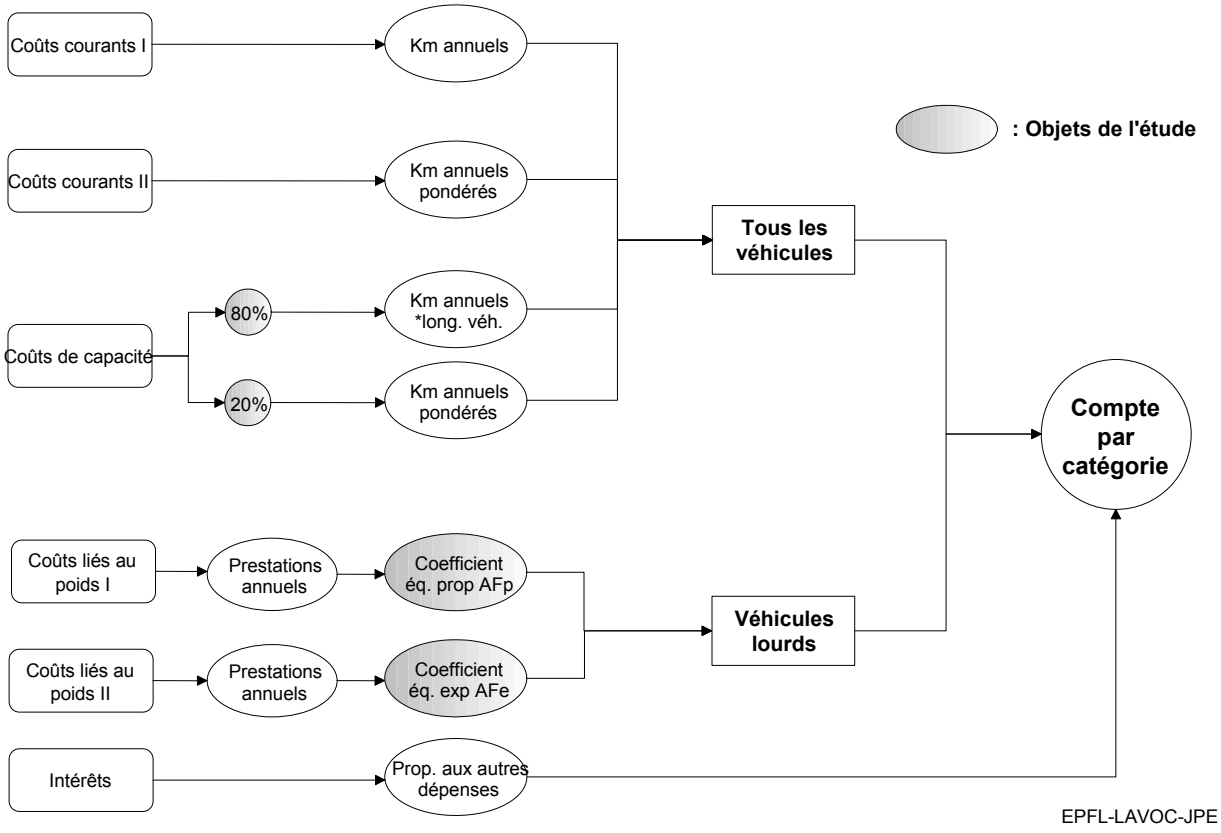
**Annex CH-6** (BFS, Dumont et al. 2000, p. 63 sur LXIX)

## Swiss account plan / Plan comptable (for the expenditures / pour les depenses)

11 Administration
11.1 Personnel
11.5 Machines et véhicules
11.53 Acquisitions
11.6 Immeubles administratifs et bureaux externes
11.63 Constructions nouvelles et agrandissement, achat de terrain
11.9 Autres frais administratifs
12 Entretien de l'exploitation
12.1 Personnel
12.2 Chaussée
12.22 Nettoyage
12.23 Service hivernal
12.3 Constructions d'art et similaires
12.37 Assainissement de chaussée et canalisations
12.38 Eclairage des routes
12.4 Parking / garage souterrain
12.43 Constructions nouvelles et agrandissement, achat de terrain
12.5 Machines outils et véhicules
12.53 Acquisitions
12.6 Ateliers et dépôts
12.63 Constructions nouvelles et agrandissement, achat de terrain
12.7 Signalisation routière
12.9 Autres entretiens d'exploitation
13 Entretien des constructions
13.1 Personnel
13.2 Chaussée
13.3 Constructions d'art et similaires
13.32 Ponts
13.33 Tunnels et galeries
13.34 Places de parcs
13.35 Pistes cyclables
13.36 Trottoirs
13.37 Assainissement de chaussée et canalisations
13.38 Eclairage des routes
13.39 Autres constructions d'art et similaires
13.8 Achats de terrains
13.9 Autres entretiens de constructions
14 Rénovation et aménagement
14.2 Chaussées
14.3 Constructions d'art et similaires
14.32 Ponts
14.33 Tunnels et galeries
14.34 Places de parcs
14.35 Pistes cyclables
14.36 Trottoirs
14.37 Assainissement de chaussée et canalisations
14.38 Eclairage des routes
14.39 Autres constructions d'art et similaires
14.7 Signalisation routière
14.8 Achats de terrain
14.9 Autres rénovations et aménagements
15 Constructions nouvelles
15.2 Chaussées
15.3 Constructions d'art et similaires
15.32 Ponts
15.33 Tunnels et galeries
15.34 Places de parcs
15.35 Pistes cyclables
15.36 Trottoirs
15.37 Assainissement de chaussée et canalisations
15.38 Eclairage des routes
15.39 Autres constructions d'art et similaires
15.7 Signalisation routière
15.8 Achats de terrain
15.9 Autres constructions nouvelles
17 Police routière
17.1 Personnel
17.5 Machines outils et véhicules
17.53 Acquisitions
17.6 Immeubles administratifs et bureaux externes
17.63 Constructions nouvelles et agrandissement, achat de terrain
17.9 Autres surveillance policière
18 Contributions
18.2 Contributions aux cantons
18.21 Pour les routes selon définition du CR
18.22 Pour la sécurité des passages à niveau
18.25 pour l'assainissement des routes
18.3 Contributions aux communes
18.31 Pour les routes selon définition du CR
18.32 Pour la sécurité des passages à niveau
18.35 Pour l'assainissement des routes
18.4 Contributions aux corporations
18.41 Pour les routes selon définition du CR
18.42 Pour la sécurité des passages à niveau
18.45 Pour l'assainissement des routes

**Annex CH-7** (BFS, Dumont et al. 2000, Annexes, p. 62 sur LXIX)

## Categories account : Organigramme du compte par catégories



**Annex CH-8** (BFS, Dumont et al. 2000, tableau 36, p. 53 sur LXIX)

**New dynamic or aggressive axle-load factors (AFa, replacing the exponential axle-load factors AFe)**

Nouveaux coefficients d'agressivité des véhicules lourds (AFa, remplacent les AFe)

AFe = coefficients de charge exponentiel

| Catégorie | Coefficients d'agressivité (AFa) |
|---|---|
| Cars/Bus publics | 0.854 |
| Cars Privés | 0.854 |
| **Camions** | |
| 2 axes, de 3501 à 5000 kg | 0.114 |
| 2 axes, de 5001 à 9000 kg | 0.141 |
| 2 axes, de 9001 à 13000 kg | 0.696 |
| 2 axes, 13001 kg et plus | 0.866 |
| 3 axes, de 13001 à 16000 kg | 0.339 |
| 3 axes, 16001 kg et plus | 0.518 |
| 4 axes, 25001 kg et plus | 0.317 |
| **Remorques de transport de marchandises** | |
| Légères | 0.060 |
| 1 axe, de 3501 à 10000 kg | 0.295 |
| 2 axes, jusqu'à 10000 kg | 0.186 |
| 2 axes, 10000 kg et plus | 0.192 |
| 3 axes, 10000 kg et plus | 0.137 |
| **Tracteurs à sellette** | |
| 2 axes, jusqu'à 3500 kg | 0.007 |
| 2 axes, de 3501 à 13000 kg | 0.255 |
| 2 axes, 13000 kg et plus | 0.471 |
| 3 axes, 13000 kg et plus | 0.328 |
| **Remorques de tracteurs (semi-remorques)** | |
| 1 axe, jusqu'à 5000 kg | 0.118 |
| 1 axe, 5000 kg et plus | 0.464 |
| 2 axes, jusqu'à 15000 kg | 0.184 |
| 2 axes, 15000 kg et plus | 0.445 |
| 3 axes, 15000 kg et plus | 0.147 |

**Annex CH-9** (BFS, Dumont et al. 2000, tableau 37, p. 55 sur LXIX)

## New percentage axle–load factors (AFp)

Nouveaux coefficients AFp (AFp = coefficients de proportionnalité)

| Catégorie | Nouveaux AFp |
|---|---|
| Cars/Bus publics | 1.799 |
| Cars Privés | 1.799 |
| **Camions** | |
| 2 axes, de 3501 à 5000 kg | 0.517 |
| 2 axes, de 5001 à 9000 kg | 0.854 |
| 2 axes, de 9001 à 13000 kg | 1.311 |
| 2 axes, 13001 kg et plus | 1.646 |
| 3 axes, de 13001 à 16000 kg | 1.618 |
| 3 axes, 16001 kg et plus | 2.229 |
| 4 axes, 25001 kg et plus | 2.543 |
| **Remorques de transport de marchandises** | |
| Légères | 0.276 |
| 1 axe, de 3501 à 10000 kg | 0.728 |
| 2 axes, jusqu'à 10000 kg | 0.797 |
| 2 axes, 10000 kg et plus | 1.250 |
| 3 axes, 10000 kg et plus | 1.762 |
| **Tracteurs à sellette** | |
| 2 axes, jusqu'à 3500 kg | 0.276 |
| 2 axes, de 3501 à 13000 kg | 1.004 |
| 2 axes, 13000 kg et plus | 1.500 |
| 3 axes, 13000 kg et plus | 2.131 |
| **Remorques de tracteurs (semi-remorques)** | |
| 1 axe, jusqu'à 5000 kg | 0.368 |
| 1 axe, 5000 kg et plus | 0.789 |
| 2 axes, jusqu'à 15000 kg | 1.225 |
| 2 axes, 15000 kg et plus | 1.685 |
| 3 axes, 15000 kg et plus | 1.716 |

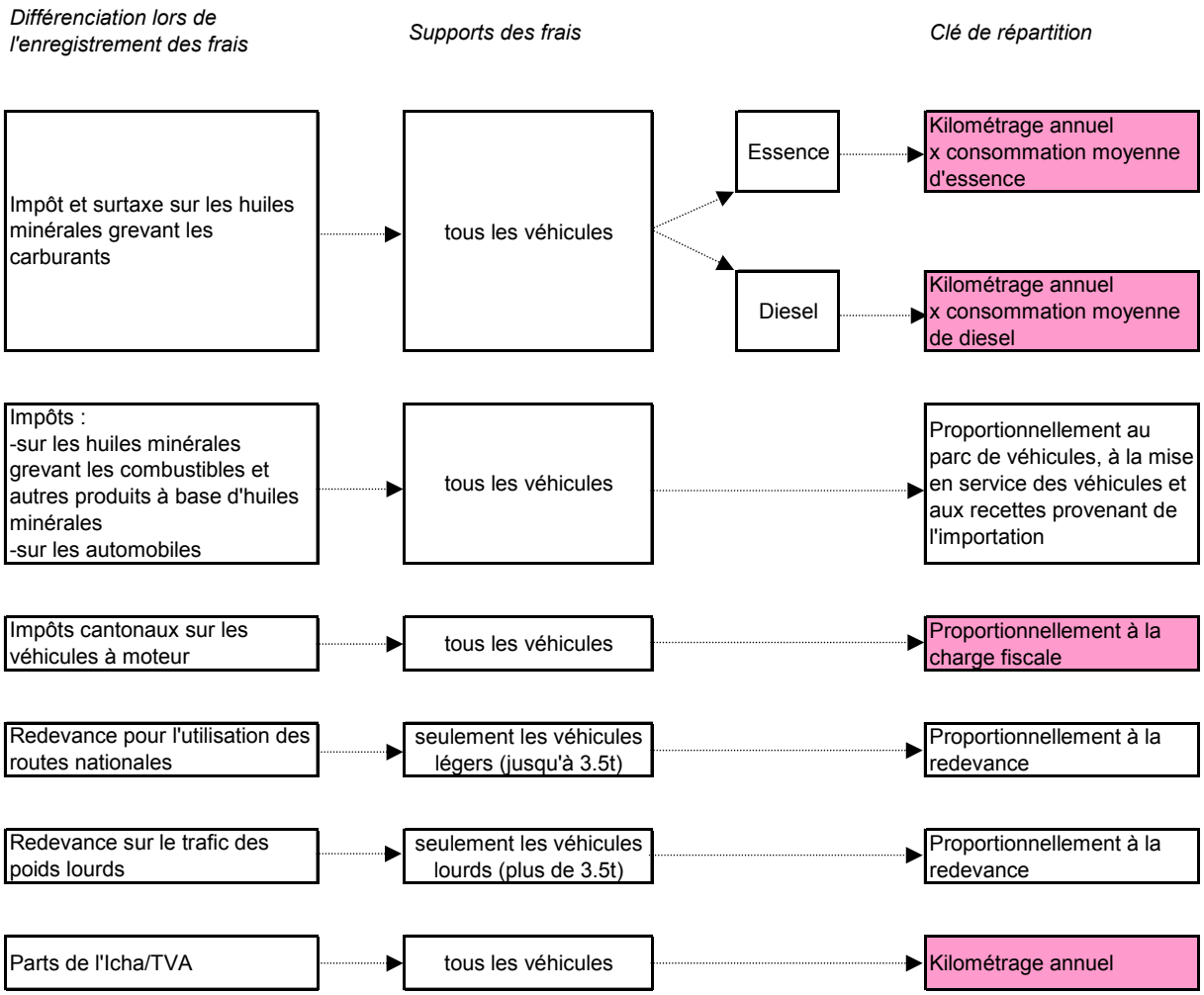
**Annex CH-10** (BFS 2004, by email from Mr. Schweizer, BFS, Jan. 10, 2005)

## Swiss transport performance in vehicle-kilometers up to 2002 (newest data, issued in 2004)

| Vehicle types | Actual road account | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|
| **Motorcycles** | 3500 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 |
| **Mopeds** | 5000 | 3700 | 3600 | 3600 | 3600 | 3600 | 3500 | 3500 |
| **Cars:** | | | | | | | | |
| **Light** | 13850 | 9700 | 9700 | 9700 | 9700 | 9700 | 9700 | 9800 |
| **Medium** | 13850 | 12200 | 12200 | 12200 | 12200 | 12300 | 12300 | 12300 |
| **Heavy** | 13850 | 13300 | 13200 | 13200 | 13100 | 13200 | 13200 | 13200 |
| **Small coaches** | 13850 | 17100 | 17200 | 17300 | 17400 | 17500 | 17500 | 17500 |
| **Light goods vehicles** | 15500 | 14300 | 14900 | 15400 | 15800 | 15800 | 15800 | 15800 |
| **Public coaches/buses** | 42370 | 49800 | 50200 | 49700 | 49900 | 51600 | 51600 | 51600 |
| **Private coaches** | 32500 | 46700 | 46300 | 46000 | 45600 | 45300 | 45300 | 45300 |
| **trucks:** | | | | | | | | |
| **2-axles (3501-5000)** | 18000 | 9200 | 9800 | 10400 | 10800 | 11800 | 6600 | 6600 |
| **2-axles (5001-9000)** | 18000 | 9200 | 9800 | 10400 | 10800 | 11800 | 6600 | 6600 |
| **2-axles (9001-13000)** | 27100 | 30000 | 31100 | 32200 | 33400 | 36700 | 27600 | 26100 |
| **2-axles (+13000)** | 38400 | 36700 | 36200 | 35700 | 37200 | 40800 | 32600 | 26700 |
| **3-axles (13000-16000)** | 43400 | 36700 | 36200 | 35700 | 37200 | 40800 | 32600 | 26700 |
| **3-axles (+16000)** | 43400 | 43700 | 43300 | 42900 | 44600 | 48900 | 37800 | 37300 |
| **4-axles (+25000)** | 43400 | 43700 | 43300 | 42900 | 44600 | 48900 | 37800 | 37300 |
| **Trailer:** | | | | | | | | |
| **Light** | 4000 | 4000 | 4000 | 4000 | 4000 | 4000 | 4000 | 4000 |
| **1-axle (3501-10000)** | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 15000 | 15000 |
| **2-axles (up to 10000)** | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 15000 | 15000 |
| **2-axles (+10000)** | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 15000 | 15000 |
| **3-axles (+10000)** | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 15000 | 15000 |
| **Tractor for semi-trailer:** | | | | | | | | |
| **2-axles (up to 3500)** | 27300 | 38200 | 36500 | 34000 | 34600 | 35100 | 22000 | 20000 |
| **2-axles (3501-13000)** | 38400 | 54300 | 54000 | 53800 | 53500 | 54300 | 25100 | 21400 |
| **2-axles (+13000)** | 41700 | 58900 | 58700 | 58400 | 58100 | 58900 | 47900 | 52600 |
| **3-axles (+13000)** | 41700 | 58900 | 58700 | 58400 | 58100 | 58900 | 47900 | 52600 |
| **Semi-trailer:** | | | | | | | | |
| **1-axle (up to 5000)** | 30000 | 30000 | 30000 | 30000 | 30000 | 30000 | 26000 | 26000 |
| **1-axle (+5000)** | 30000 | 30000 | 30000 | 30000 | 30000 | 30000 | 26000 | 26000 |
| **2-axles (up to 15000)** | 30000 | 30000 | 30000 | 30000 | 30000 | 30000 | 26000 | 26000 |
| **2-axles (+15000)** | 30000 | 30000 | 30000 | 30000 | 30000 | 30000 | 26000 | 26000 |
| **3-axles (+15000)** | 30000 | 30000 | 30000 | 30000 | 30000 | 30000 | 26000 | 26000 |

**Annex CH-11** (BFS, Rev 2000, p. 24, Tab. 6)

## Revenue allocation to vehicle categories



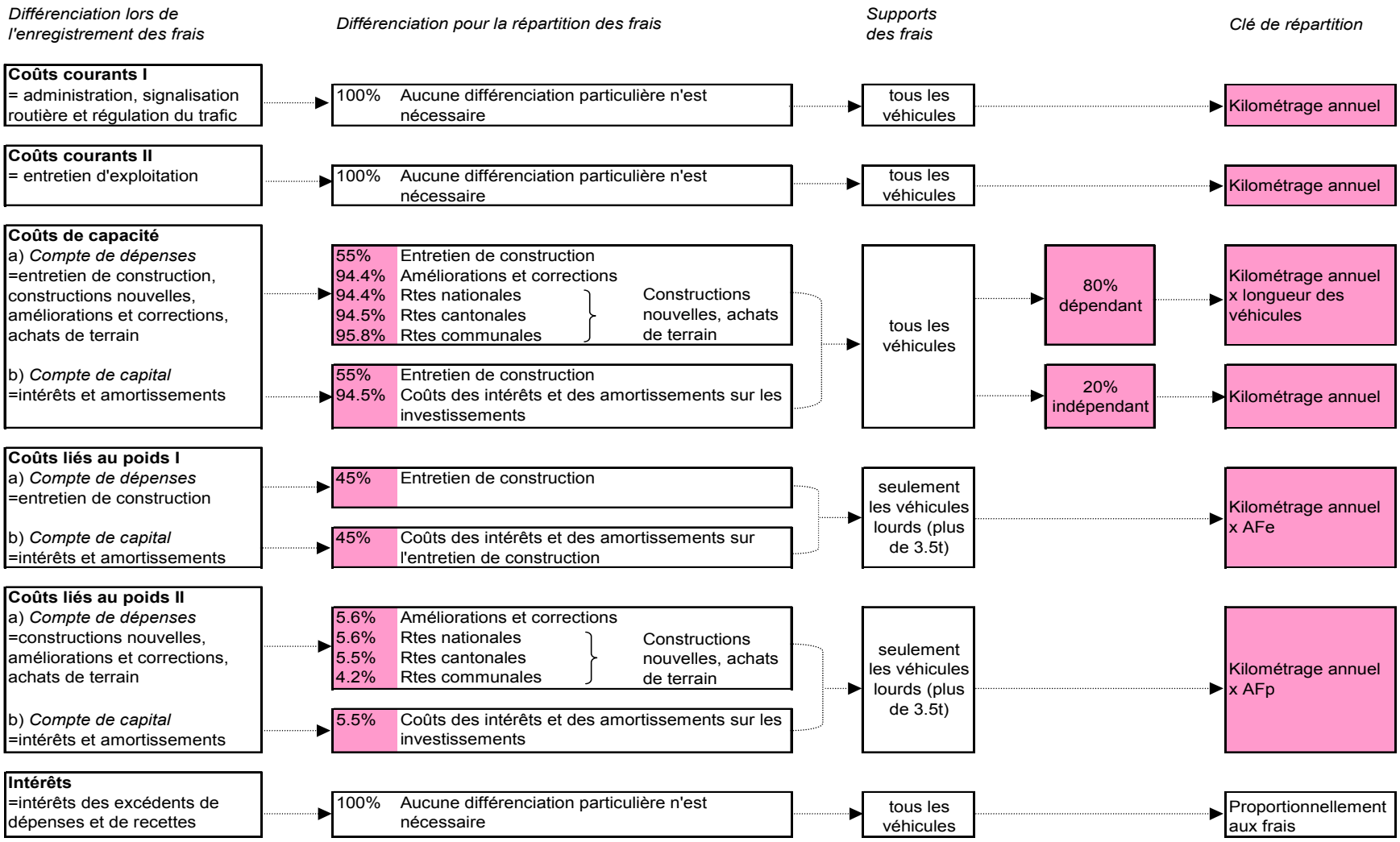
**Annex CH-12** (BFS, Rev 2000, p. 23, Tabelle 5)

**Scheme of cost allocation to the different vehicle types according to the Kommission Nydegger, 1982** (see next page)

In 2000 (rev 2000, p. 25, Tab. 7), the proportions for the weight-related costs II have changed (see also chapter 4):

| **Proportions** | **New** | *Old* |
|---|---|---|
| **Expenditures account:** | | |
| Improvement and enlargement | **9.06 %** | *5.60 %* |
| New construction and land purchase | | |
| national roads | **5.30 %** | *5.60 %* |
| cantonal roads | **4.90 %** | *5.50 %* |
| municipal roads | **7.12 %** | *4.20 %* |
| **Capital account :** | | |
| Investment expenditures | **7.05 %** | *5.50 %* |

Weight-related costs I: The exponential axle-load factor AFe has been replaced with the **dynamic or aggressive axle-load factor AFa.**


Différenciation lors de l'enregistrement des frais
Différenciation pour la répartition des frais
Supports des frais
Clé de répartition
Coûts courants I
= administration, signalisation routière et régulation du trafic
100% Aucune différenciation particulière n'est nécessaire
tous les véhicules
Kilométrage annuel
Coûts courants II
= entretien d'exploitation
100% Aucune différenciation particulière n'est nécessaire
tous les véhicules
Kilométrage annuel
Coûts de capacité
a) Compte de dépenses
=entretien de construction, constructions nouvelles, améliorations et corrections, achats de terrain
55% Entretien de construction
94.4% Améliorations et corrections
94.4% Rtes nationales
94.5% Rtes cantonales
95.8% Rtes communales
Constructions nouvelles, achats de terrain
b) Compte de capital
=intérêts et amortissements
55% Entretien de construction
94.5% Coûts des intérêts et des amortissements sur les investissements
tous les véhicules
80% dépendant
20% indépendant
Kilométrage annuel x longueur des véhicules
Kilométrage annuel
Coûts liés au poids I
a) Compte de dépenses
=entretien de construction
b) Compte de capital
=intérêts et amortissements
45% Entretien de construction
45% Coûts des intérêts et des amortissements sur l'entretien de construction
seulement les véhicules lourds (plus de 3.5t)
Kilométrage annuel x AFe
Coûts liés au poids II
a) Compte de dépenses
=constructions nouvelles, améliorations et corrections, achats de terrain
5.6% Améliorations et corrections
5.6% Rtes nationales
5.5% Rtes cantonales
4.2% Rtes communales
Constructions nouvelles, achats de terrain
b) Compte de capital
=intérêts et amortissements
5.5% Coûts des intérêts et des amortissements sur les investissements
seulement les véhicules lourds (plus de 3.5t)
Kilométrage annuel x AFp
Intérêts
=intérêts des excédents de dépenses et de recettes
100% Aucune différenciation particulière n'est nécessaire
tous les véhicules
Proportionnellement aux frais

**Annex CH-13**

**Compte routier suisse 2002 / Swiss road account 2002 (in French)**

BFS, PM 2004, Communiqué de presse/Press release, No 0350-0407-90, Neuchatel, le 24 aout 2004/August 24, 2004).

Office fédéral de la statistique
Bundesamt für Statistik
Ufficio federale di statistica
Uffizi federal da statistica
Swiss Federal Statistical Office
OFS BFS UST

COMMUNIQUÉ DE PRESSE
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11 Transports et communications
Verkehr und Nachrichtenwesen
Trasporti e comunicazioni

N° 0351-0407-90
Neuchâtel, le 24 août 2004

**Compte routier 2002**

# Le trafic routier continue de couvrir les coûts d'infrastructure qu'il engendre

**Le compte routier publié par l'Office fédéral de la statistique (OFS) présente pour 2002 un excédent de couverture de 778 millions de francs. Le trafic routier privé couvre donc l'intégralité des coûts directs engendrés pour la construction, l'entretien et l'exploitation du réseau routier. Le compte routier ne prend toutefois pas en compte les coûts externes. Les coûts imputables du compte de capital s'élèvent à 6820 millions de francs. Les recettes imputables s'établissent quant à elles à 7598 millions de francs. Tant les dépenses que les recettes ont quelque peu diminué par rapport à l'année précédente.**

Selon le mandat politique, les utilisateurs du réseau routier doivent couvrir eux-mêmes, à long terme, les dépenses qu'ils engendrent pour la construction, l'entretien et l'exploitation des routes suisses. Le compte routier de l'Office fédéral de la statistique calcule le degré de couverture des coûts de deux manières. Le ***compte de dépenses*** met en balance les dépenses courantes d'une année avec les recettes tirées du trafic privé motorisé. Les dépenses non couvertes par des recettes sont additionnées année après année. Un intérêt est calculé sur ces dernières. Les capitaux investis dans le réseau routier sont ainsi entièrement imputés au trafic motorisé. Dans le ***compte de capital***, les capitaux sont investis en fonction de la durée de vie des ouvrages. Sur ces investissements sont ensuite calculés un amortissement et un intérêt. Les frais de gestion sont intégralement amortis chaque année.

## Recettes

Ces trois dernières années, les recettes imputables au compte routier se sont maintenues à peu près au même niveau (environ 7,6 milliards de francs), après avoir progressé de 1995 à 2000 (+3,5% en moyenne). Depuis 2000, les recettes provenant de l'impôt sur les huiles minérales affichent une légère tendance à la baisse, reculant de 1,6% ou de 75 à 80 millions de francs chaque année. Cette baisse est compensée en partie par la progression constante des impôts et des taxes cantonaux sur les véhicules à moteur, qui augmentent chaque année de plus de 3% (environ 50 millions de francs) depuis 1995. La redevance pour l'utilisation des routes nationales (vignette) se maintient quasiment au même niveau que les deux années précédentes (270 millions de francs).

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L'introduction en 2001 de la redevance sur le trafic des poids lourds liée aux prestations (RPLP) a permis de compenser les dépenses engendrées par l'arrivée des 40 tonnes sur le réseau routier, ainsi que les coûts des contrôles du trafic des poids lourds. La part imputable de la RPLP s'élève à 378 millions de francs. Les recettes provenant de la RPLP qui sont utilisées pour couvrir les coûts externes (386 millions de francs) ne sont pas prises en compte dans le compte routier. Signalons encore que les coûts externes ont été estimés en 1993 à plus de 3,8 milliards de francs. Ces chiffres sont en voie d'actualisation.

En résumé, voici comment se sont réparties en 2002 les recettes provenant du trafic routier : impôt sur les huiles minérales : 63% (4755 millions), impôts cantonaux sur les véhicules à moteur : 25% (1899 millions), RPLP : 5% (378 millions), vignette autoroutière : 4% (270 millions), taxes sur l'importation de véhicules à moteur : 3% (229 millions), TVA : 1% (67 millions).

## Dépenses

En 2002, près de 6893 millions de francs ont été dépensés pour les routes suisses (6898 millions en 2001). 2658 millions sont allés aux routes nationales, 2043 millions aux routes cantonales et 2192 millions aux routes communales (chiffres provisoires). Dans le ***compte de dépenses***, les dépenses imputables s'élèvent à 6800 millions de francs (y compris les intérêts calculés sur les soldes négatifs, qui s'élèvent à 1339 millions). Si l'on compare les dépenses courantes avec les recettes imputables, on obtient un taux de couverture de 112% ou un excédent de couverture de 798 millions de francs. Dans le ***compte de capital***, les coûts atteignent 6820 millions de francs. Il en résulte un excédent de couverture de 778 millions de francs, correspondant à un degré d'équilibre financier de 111%.

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Service de presse

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***Renseignements:***
Martin Schweizer, OFS, section Transports, tél. : 032 713 68 93

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Service de presse OFS, tél. : 032 713 60 13; fax : 032 713 63 46

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Abonnement aux communiqués de presse par e-mail sous : http://www.news-stat.admin.ch

**Bases de calcul**

Les charges liées au trafic motorisé privé sont portées au passif du compte routier. Elles comprennent les coûts de construction et d'entretien des routes, les coûts de régulation du trafic et de signalisation, les frais administratifs et les coûts du capital. Ces dépenses sont comptabilisées dans leur totalité pour les routes nationales, à raison de 90% pour les routes cantonales et à raison de 70% pour les routes communales, en vertu du principe qui veut que les cantons et les communes doivent construire et entretenir une infrastructure routière de base, indépendamment du type de moyen de transport. C'est pourquoi cette quote-part n'est pas imputée au trafic privé des véhicules à moteur. Elle permet par ailleurs de déduire des éléments de coûts qui ne peuvent pas être saisis avec la méthode de relevé, tels que ceux liés aux parties de la chaussée qui sont réservées aux transports publics, aux routes interdites au trafic motorisé et à certaines parties du réseau de pistes cyclables et des zones piétonnes.

Ces coûts sont comparés aux recettes à prendre en compte. Ces recettes se composent de l'impôt sur les huiles minérales, des impôts sur les automobiles, des droits d'entrée sur les véhicules et les accessoires importés, des impôts cantonaux sur les véhicules à moteur, des autres redevances routières (vignette autoroutière, taxe poids lourds) ainsi que des parts imputables de la TVA.

Les dépenses routières effectives sont calculées sur la base des comptes de la Confédération, des cantons et des communes. Les chiffres relatifs aux routes nationales et cantonales sont définitifs ; il se peut que des corrections minimes y soient encore apportées. De même, les recettes imputables sont connues. Ce qui manque, ce sont des chiffres précis pour les routes communales. Les dépenses pour les routes communales ont été extrapolées sur la base d'un échantillon représentatif de 55 communes de référence.

Les bases méthodologiques détaillées peuvent être consultées sur le site Internet de l'OFS. Les « Actualités OFS » consacrées au compte routier 2001 contiennent également une description détaillée de la méthode.

**Tableau 1: Recettes imputables au compte de capital et au compte de dépenses [en mio de francs]**

| | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|
| Impôts imputables sur les huiles minérales | 4 345 | 4 461 | 4 420 | 4 645 | 4 789 | 4 910 | 4 835 | 4 755 |
| *Impôt sur l'essence* | *2 034* | *2 076* | *2 085* | *2 188* | *2 230* | *2 253* | *2 190* | *2 135* |
| *Impôt sur le diesel* | *537* | *558* | *554* | *596* | *634* | *678* | *701* | *711* |
| *Surtaxe sur l'essence* | *1 445* | *1 492* | *1 458* | *1 518* | *1 553* | *1 576* | *1 527* | *1 489* |
| *Surtaxe sur le diesel* | *329* | *335* | *323* | *343* | *372* | *403* | *417* | *420* |
| Produits des droits d'entrée sur les véhicules | 130 | 132 | 165 | 202 | 228 | 243 | 259 | 229 |
| Impôts cantonaux sur les véhicules à moteur | 1 527 | 1 608 | 1 655 | 1 687 | 1 749 | 1 798 | 1 836 | 1 899 |
| Vignette autoroutière | 237 | 243 | 249 | 258 | 262 | 269 | 274 | 270 |
| Part de la RPLP retenue pour les routes | 174 | 169 | 167 | 174 | 176 | 340 | 354 | 378 |
| Part de la TVA | -1 | 3 | 3 | 17 | 24 | 48 | 64 | 67 |
| **Total des recettes imputables** | **6 412** | **6 616** | **6 659** | **6 983** | **7 228** | **7 608** | **7 622** | **7 598** |
| *Indice des recettes (1995 = 100)* | *100* | *103* | *104* | *109* | *113* | *119* | *119* | *118* |
| RPLP ne servant pas à des dépenses routières [1] | | | | | | | 316 | 386 |

[1] Voir compte de l'état, page 482b

**Tableau 2: Compte global [en mio de francs]**

| | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 [2] |
|---|---|---|---|---|---|---|---|---|
| Recettes à porter en compte | 6 412 | 6 616 | 6 659 | 6 983 | 7 228 | 7 608 | 7 622 | 7 598 |
| **Compte de capital** | | | | | | | | |
| *Coûts imputables* | *6 450* | *6 557* | *6 605* | *6 631* | *6 803* | *6 768* | *6 947* | *6 965* |
| *Intérêts sur les soldes cumulés* | *-8* | *-12* | *-14* | *-32* | *-51* | *-88* | *-121* | *-145* |
| Coûts imputables et intérêts | 6 441 | 6 545 | 6 591 | 6 599 | 6 752 | 6 680 | 6 826 | 6 820 |
| Degré d'équilibre financier [%] | 100 | 101 | 101 | 106 | 107 | 114 | 112 | 111 |
| Excédent ou insuffisance de couverture [1] | -29 | 71 | 68 | 384 | 476 | 928 | 796 | 778 |
| **Compte de dépenses** | | | | | | | | |
| *Dépenses imputables* | *5 021* | *4 918* | *4 935* | *5 007* | *5 395* | *5 363* | *5 445* | *5 461* |
| *Intérêts sur les soldes cumulés* | *1 845* | *1 818* | *1 788* | *1 674* | *1 596* | *1 498* | *1 436* | *1 339* |
| Dépenses et amortissement imputables | 6 866 | 6 736 | 6 723 | 6 681 | 6 991 | 6 861 | 6 881 | 6 800 |
| Degré de couverture [en %] | 93 | 98 | 99 | 105 | 103 | 111 | 111 | 112 |
| Excédent ou insuffisance de couverture [1] | -454 | -120 | -64 | 302 | 237 | 747 | 741 | 798 |

[1] Insuffisance de couverture = - / Excédent de couverture = +

[2] Résultats provisoires

**Tableau 3: Dépenses brutes pour les routes nationales, cantonales et communales, TVA incluse [en mio de francs]**

| | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 [1)] |
|---|---|---|---|---|---|---|---|---|
| **Routes nationales** | **2 359** | **2 319** | **2 343** | **2 386** | **2 542** | **2 522** | **2 557** | **2 658** |
| Constructions nouvelles | 1 638 | 1 679 | 1 597 | 1 578 | 1 646 | 1 680 | 1 657 | 1 698 |
| Améliorations et corrections | 48 | 34 | 41 | 94 | 100 | 52 | 61 | 89 |
| Acquisition de terrains | 129 | 101 | 95 | 77 | 99 | 83 | 51 | 53 |
| Entretien de construction | 249 | 204 | 309 | 334 | 372 | 395 | 455 | 470 |
| Entretien courant | 141 | 144 | 141 | 142 | 158 | 142 | 152 | 150 |
| Administration | 23 | 23 | 22 | 21 | 23 | 23 | 24 | 24 |
| Signalisation routière | | | | | | | | |
| Régulation du trafic | 130 | 134 | 138 | 140 | 144 | 147 | 157 | 174 |
| **Routes cantonales** | **1 900** | **1 773** | **1 765** | **1 800** | **2 040** | **2 035** | **2 104** | **2 043** |
| Constructions nouvelles | 81 | 73 | 178 | 231 | 305 | 289 | 266 | 215 |
| Améliorations et corrections | 702 | 625 | 524 | 538 | 648 | 646 | 660 | 570 |
| Acquisition de terrains | 73 | 35 | 39 | 33 | 45 | 39 | 29 | 33 |
| Entretien de construction | 184 | 196 | 197 | 186 | 200 | 174 | 215 | 242 |
| Entretien courant | 495 | 472 | 465 | 449 | 487 | 505 | 537 | 533 |
| Administration | 99 | 97 | 91 | 86 | 87 | 98 | 100 | 102 |
| Signalisation routière | 57 | 53 | 38 | 36 | 37 | 34 | 29 | 36 |
| Régulation du trafic | 209 | 222 | 233 | 241 | 231 | 250 | 267 | 312 |
| **Routes communales** | **1 993** | **2 058** | **2 068** | **2 094** | **2 214** | **2 228** | **2 238** | **2 192** |
| Constructions nouvelles | 77 | 71 | 93 | 90 | 135 | 173 | 155 | 149 |
| Améliorations et corrections | 453 | 500 | 498 | 471 | 424 | 451 | 414 | 397 |
| Acquisition de terrains | 41 | 41 | 40 | 38 | 24 | 20 | 21 | 21 |
| Entretien de construction | 220 | 233 | 229 | 192 | 168 | 229 | 193 | 185 |
| Entretien courant | 870 | 873 | 878 | 966 | 1 116 | 1 001 | 1 114 | 1 097 |
| Administration | 121 | 123 | 117 | 117 | 131 | 138 | 122 | 125 |
| Signalisation routière | 62 | 65 | 62 | 52 | 52 | 51 | 52 | 50 |
| Régulation du trafic | 150 | 152 | 151 | 168 | 164 | 165 | 166 | 168 |
| **Total de toutes les routes** | **6 252** | **6 151** | **6 176** | **6 280** | **6 796** | **6 784** | **6 898** | **6 893** |
| Constructions nouvelles | 1 796 | 1 823 | 1 868 | 1 899 | 2 086 | 2 142 | 2 078 | 2 061 |
| Améliorations et corrections | 1 203 | 1 159 | 1 063 | 1 103 | 1 172 | 1 149 | 1 135 | 1 056 |
| Acquisition de terrains | 243 | 177 | 174 | 148 | 168 | 142 | 101 | 108 |
| Entretien de construction | 653 | 633 | 735 | 712 | 740 | 798 | 863 | 897 |
| Entretien courant | 1 506 | 1 489 | 1 484 | 1 557 | 1 761 | 1 648 | 1 803 | 1 780 |
| Administration | 243 | 243 | 230 | 224 | 241 | 259 | 246 | 251 |
| Signalisation routière | 119 | 118 | 100 | 88 | 89 | 85 | 82 | 86 |
| Régulation du trafic | 489 | 508 | 522 | 549 | 539 | 562 | 590 | 654 |

[1)] Résultats provisoires

**Tableau 4: Dépenses routières imputables au compte de dépenses [en mio de francs]**

| | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 [1] |
|---|---|---|---|---|---|---|---|---|
| Routes nationales | | | | | | | | |
| Dépenses brutes routes nationales | 2 358 | 2 319 | 2 343 | 2 386 | 2 542 | 2 522 | 2 557 | 2 658 |
| Taxe sur la valeur ajoutée (TVA) | 111 | 112 | 115 | 120 | 145 | 146 | 151 | 157 |
| Total des dépenses (TVA non comprise) | 2 247 | 2 207 | 2 228 | 2 266 | 2 397 | 2 376 | 2 406 | 2 501 |
| Taxes pour roues et taxes de parking | | | | | | | | |
| Contributions des privés et de tiers | | | | | | | | |
| Total des dépenses nettes | 2 247 | 2 207 | 2 228 | 2 266 | 2 397 | 2 376 | 2 406 | 2 501 |
| *Quotité* | *100%* | *100%* | *100%* | *100%* | *100%* | *100%* | *100%* | *100%* |
| Dépenses imputables [2] | 2 247 | 2 207 | 2 228 | 2 266 | 2 397 | 2 376 | 2 406 | 2 501 |
| Routes cantonales | | | | | | | | |
| Dépenses brutes routes cantonales | 1 900 | 1 773 | 1 765 | 1 800 | 2 040 | 2 035 | 2 103 | 2 043 |
| Taxe sur la valeur ajoutée (TVA) | 77 | 71 | 71 | 74 | 99 | 98 | 102 | 96 |
| Total des dépenses (TVA non comprise) | 1 823 | 1 702 | 1 694 | 1 726 | 1 941 | 1 937 | 2 002 | 1 948 |
| Taxes pour roues et taxes de parking | 41 | 44 | 46 | 47 | 52 | 55 | 56 | 53 |
| Contributions des privés et de tiers | 9 | 11 | 9 | 6 | 5 | 7 | 12 | 7 |
| Total des dépenses nettes | 1 773 | 1 647 | 1 639 | 1 673 | 1 884 | 1 875 | 1 934 | 1 888 |
| *Quotité* | *90%* | *90%* | *90%* | *90%* | *90%* | *90%* | *90%* | *90%* |
| Dépenses imputables [2] | 1 596 | 1 482 | 1 475 | 1 506 | 1 696 | 1 688 | 1 740 | 1 699 |
| Routes communales | | | | | | | | |
| Dépenses brutes routes communales | 1 994 | 2 058 | 2 068 | 2 094 | 2 214 | 2 228 | 2 238 | 2 192 |
| Taxe sur la valeur ajoutée (TVA) | 75 | 78 | 79 | 77 | 93 | 97 | 97 | 87 |
| Total des dépenses (TVA non comprise) | 1 919 | 1 980 | 1 989 | 2 017 | 2 121 | 2 131 | 2 141 | 2 105 |
| Taxes pour roues et taxes de parking | 235 | 152 | 172 | 176 | 181 | 191 | 210 | 225 |
| Contributions des privés et de tiers | | 70 | 54 | 75 | 76 | 82 | 74 | 80 |
| Total des dépenses nettes | 1 684 | 1 758 | 1 763 | 1 766 | 1 864 | 1 858 | 1 856 | 1 800 |
| *Quotité* | *70%* | *70%* | *70%* | *70%* | *70%* | *70%* | *70%* | *70%* |
| Dépenses imputables [2] | 1 179 | 1 231 | 1 234 | 1 236 | 1 305 | 1 301 | 1 299 | 1 260 |
| Total des dépenses routières imputables [2] | 5 021 | 4 918 | 4 935 | 5 007 | 5 395 | 5 363 | 5 445 | 5 461 |

[1] Résultats provisoires
[2] Avant le calcul de l'intérêt sur les excédents et insuffisances cumulés

**Tableau 5: Coûts imputables au compte de capital [en mio de francs]**

| | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 [1] |
|---|---|---|---|---|---|---|---|---|
| Routes nationales | | | | | | | | |
| Valeur résiduelle | 28 287 | 29 121 | 29 922 | 30 699 | 31 526 | 32 284 | 32 999 | 33 743 |
| *Intérêt sur la valeur résiduelle* | *1 499* | *1 514* | *1 526* | *1 474* | *1 450* | *1 421* | *1 419* | *1 384* |
| *Amortissements* [2] | *1 075* | *1 130* | *1 191* | *1 251* | *1 310* | *1 364* | *1 416* | *1 465* |
| Coûts de capital | 2 575 | 2 644 | 2 717 | 2 725 | 2 760 | 2 784 | 2 835 | 2 848 |
| Coûts d'exploitation (TVA non comprise) | 291 | 297 | 296 | 299 | 320 | 307 | 328 | 342 |
| Total des coûts | 2 865 | 2 941 | 3 013 | 3 024 | 3 079 | 3 091 | 3 162 | 3 190 |
| *Quotité* | *100%* | *100%* | *100%* | *100%* | *100%* | *100%* | *100%* | *100%* |
| Coûts imputables [3] | 2 865 | 2 941 | 3 013 | 3 024 | 3 079 | 3 091 | 3 162 | 3 190 |
| Routes cantonales | | | | | | | | |
| Valeur résiduelle | 14 194 | 14 413 | 14 641 | 14 912 | 15 350 | 15 714 | 16 072 | 16 316 |
| *Intérêt sur la valeur résiduelle* | 752 | 750 | 747 | 716 | 706 | 691 | 691 | 669 |
| *Amortissements* [2] | 608 | 605 | 611 | 629 | 652 | 671 | 691 | 705 |
| Coûts de capital | 1 360 | 1 354 | 1 358 | 1 345 | 1 358 | 1 363 | 1 382 | 1 374 |
| Coûts d'exploitation (TVA non comprise) | 835 | 820 | 805 | 790 | 816 | 858 | 905 | 954 |
| Total des coûts | 2 195 | 2 174 | 2 163 | 2 135 | 2 174 | 2 221 | 2 287 | 2 328 |
| *Quotité* | *90%* | *90%* | *90%* | *90%* | *90%* | *90%* | *90%* | *90%* |
| Coûts imputables [3] | 1 976 | 1 957 | 1 947 | 1 921 | 1 957 | 1 999 | 2 058 | 2 095 |
| Routes communales | | | | | | | | |
| Valeur résiduelle | 12 784 | 12 853 | 12 935 | 12 918 | 12 848 | 12 881 | 12 825 | 12 746 |
| *Intérêt sur la valeur résiduelle* | 678 | 668 | 660 | 620 | 591 | 567 | 552 | 523 |
| *Amortissements* [2] | 616 | 627 | 639 | 644 | 646 | 653 | 654 | 651 |
| Coûts de capital | 1 294 | 1 296 | 1 299 | 1 265 | 1 237 | 1 220 | 1 205 | 1 174 |
| Coûts d'exploitation (TVA non comprise) | 1 005 | 1 074 | 1 054 | 1 144 | 1 288 | 1 177 | 1 259 | 1 225 |
| Total des coûts | 2 299 | 2 369 | 2 352 | 2 408 | 2 526 | 2 397 | 2 464 | 2 399 |
| *Quotité* | *70%* | *70%* | *70%* | *70%* | *70%* | *70%* | *70%* | *70%* |
| Coûts imputables [3] | 1 609 | 1 658 | 1 647 | 1 686 | 1 768 | 1 678 | 1 725 | 1 679 |
| Total des coûts imputables [3] | 6 450 | 6 557 | 6 605 | 6 631 | 6 803 | 6 768 | 6 947 | 6 965 |

[1] Résultats provisoires
[2] Constructions nouvelles, améliorations/corrections et entretien de construction
[3] Avant le calcul de l'intérêt sur les excédents et insuffisances cumulés

**Annex CH-14** (« Rapport pour Schweizer, OFS » by **Jacques Perret**, March 21, 2005)

**Explanations for calculating the new dynamic or aggressive axle-load factor (AFa) used for the allocation of the weight-related costs I (in French)**

# Contexte

Le présent rapport répond à des questions de M. Martin Schweizer concernant la méthode de calcul développée par le soussigné Jacques Perret pour **définir la clé de répartition des coûts liés au poids I** entre les diverses catégories du compte routier.

# Remarque préliminaire

Une des conclusions du **rapport du LAVOC** (see **annex CH-14.1**, separate file) a été de proposer de remplacer les coefficients Afe par des **« coefficients d'agressivité »**. Elle rend donc impossible de calculer directement les valeurs des coefficients par la simple utilisation d'une loi de puissance.

Cette proposition a été adoptée par l'OFS et le compte routier actuel utilise des « coefficients d'agressivité ». Ces coefficients présentent l'avantage que ils sont obtenus à partir de lois de puissance permettant le calcul du trafic équivalent (valeur de la puissance égale à 4) et que c'est bien ce dernier qui donne le potentiel de dégradation des charges de trafic. (C'est le trafic équivalent qui sert de base au dimensionnement des chaussées routières ainsi qu'à leur renforcement). Les « coefficients d'agressivité » correspondent aux nombres d'essieux équivalents d'un véhicule donné ramené à la charge moyenne qu'il transporte.

Les coefficients Afe utilisaient une puissance de 2,5 obtenue de façon discutable et dont il a été montré qu'elle dépendait du type de véhicules considérés. (L'essentiel de ces explications peut être obtenu au chapitre 7.4.2 du rapport du LAVOC).

# Questions de l'e-mail de M. Schweizer du 9 février 2005 :

## *La puissance 4 :*

*- quel est le calcul pour arriver à une puissance de 4 ?*

Il n'y a pas de calcul à proprement parler. La puissance 4 est issue de l'essai AASHO et à partir de régressions faites sur des coefficients d'équivalence obtenus empiriquement. Les lois de puissance utilisées dans le domaine de la construction routière sont des

approximations des tables de coefficients du test AASHO. **Les normes suisses font directement référence aux tables de l'essai AASHO et ne mentionne pas la loi de puissance**. Je vous donne ci-dessous les coefficients d'équivalence figurant dans la norme suisse pour la définition du trafic équivalent pour un essieu simple ainsi qu'une comparaison avec les résultats obtenus avec des lois de puissance (en admettant 4, 4.5 et 5 pour la puissance).

| to | Norme | Puissance 4 | Puissance 4.5 | Puissance 5 |
|---|---|---|---|---|
| 1 | 0.0005 | 0.0002 | 0.0001 | 0.0000 |
| 2 | 0.006 | 0.004 | 0.002 | 0.001 |
| 3 | 0.02 | 0.02 | 0.01 | 0.01 |
| 4 | 0.07 | 0.06 | 0.04 | 0.03 |
| 5 | 0.15 | 0.14 | 0.11 | 0.09 |
| 6 | 0.29 | 0.29 | 0.25 | 0.21 |
| 7 | 0.53 | 0.54 | 0.50 | 0.46 |
| 8.16 | 1 | 1 | 1 | 1 |
| 9 | 1.52 | 1.48 | 1.55 | 1.63 |
| 10 | 2.40 | 2.26 | 2.50 | 2.76 |
| 11 | 3.66 | 3.30 | 3.83 | 4.45 |
| 12 | 5.40 | 4.68 | 5.67 | 6.88 |
| 13 | 7.76 | 6.44 | 8.13 | 10.26 |
| 14 | 10.87 | 8.66 | 11.35 | 14.87 |
| 15 | 14.91 | 11.42 | 15.48 | 20.99 |
| 16 | 20.06 | 14.78 | 20.70 | 28.98 |
| 17 | 26.54 | 18.84 | 27.19 | 39.25 |
| 18 | 34.59 | 23.68 | 35.17 | 52.23 |

*Figure 1: Essieux équivalents à partir de la norme SN 640 320 ou à partir de lois de puissance*

Même si ce tableau montre que la meilleure approximation serait obtenue avec une puissance de 4.5, c'est en général une puissance de 4 qui est utilisée pour approximer le trafic équivalent. Je vous donne en annexe un fichier Excel montrant les calculs (Approximation ESAL, see **annex CH-14.2**, separate file).

## *Coefficients d'agressivité*

*- existe-t-il une documentation détaillée pour la construction des coefficients ?*

*- qui peut-nous expliquer les tableaux ci-dessous*

Premièrement, il faut être conscient que **les « coefficients d'agressivité » ne peuvent être déterminés que par des spécialistes de la construction routière**, car ils nécessitent la définition de certaines grandeurs propres à ce domaine et nécessitant des compétences d'experts.

Les « coefficients d'agressivité » ont été calculés dans des fichiers de calcul Excel. (Nous nous centrerons sur l'explication des coefficients remplaçant les Afe, les Afp utilisant la même méthode mais simplifiée).

Le calcul des coefficients Afe se fait dans la feuille intitulée **« Afe simple »** du classeur **« Afe.xls »** (see **annex CH-14.3**, separate file). Cette feuille contient une ligne pour chacune des catégories de véhicules utilisés par le compte routier.

Chaque catégorie est « fabriquée » en additionnant les essieux servant à la composition des véhicules (colonne B et C). A titre d'exemples, il est admis que les bus ou les cars (ligne 9) sont composés d'un essieu simple limité à 10 to à l'avant et d'un essieu simple limité à 11,5 to à l'arrière (noté 12 to), que les camions à 4 axes (ligne 18) sont composés d'un essieu double (tandem) limité à 16 to à l'avant et d'un essieu double (tandem) limité à 18 to à l'arrière.

Nous laissons quelques instants la feuille « Afe simple » pour expliquer le fonctionnement des autres feuilles dans lesquels les essieux équivalents sont calculés.

Pour chaque type d'essieu existant, on calcule le nombre d'essieux équivalents à partir de pesages WIM. Ces calculs se trouvent dans les feuilles d'essieu **(« ESi8t »**, **« ESi10t »)**, etc. Ils sont basées sur l'utilisation de la loi de puissance proposée par l'OCDE pour définir l'agressivité d'un véhicule ($ 7.4.2.3 du rapport), formule qui permet de tenir compte de la technologie des véhicules.

Les données WIM sont introduites sous forme de pourcentage de répartition des charges (colonnes D). Les colonnes E, F et G servent à calculer les essieux équivalents pour différents types de pneu (jumelés, supersingle ou single) et différents types d'essieux (simple, tandem ou tridem). Les coefficients $k_1$ (configuration des essieux) et $k_2$ (type de pneus) de la formule de l'OCDE sont respectivement introduits dans les cellules L3 à L5 (toujours la même valeur pour un essieu est défini, on aurait pu n'utiliser qu'une cellule) et dans les cellules L9 à L11.

Ces valeurs sont ensuite multipliées entre elles dans les cellules E3 à G3 pour être introduites dans le calcul des essieux équivalents de chaque charge d'essieu qui est effectué dans les colonnes E à G. Ce dernier calcul nécessite en outre la définition de la puissance (cellule L22) et l'essieu de référence (cellule L23). Les essieux équivalents sont ensuite pondérés selon les comptages WIM dans les colonnes H à J, pour être sommés dans les cellules H45 à G45.

On dispose de la sorte des coefficients pour les différents types de pneus. Il reste alors à définir la répartition des différents types de pneus utilisé sur le type d'essieux étudié (cellules L16 à L18) et le nombre d'essieux équivalent est obtenu dans la cellule K45. Signalons pour en finir avec les feuilles d'essieu qu'elles contiennent également le calcul de la charge moyenne enregistrée par les comptages WIM (cellule K51).

Les valeurs ainsi obtenues pour chaque essieu sont récapitulées à la ligne 3 de la feuille **« Afe simple »** pour être ensuite utilisées dans les colonnes H et I. On reprend également la charge moyenne de chaque axe selon les comptages WIM (ligne 4). La colonne D contient le poids moyen de chaque catégorie qui est déterminé comme la moyenne entre le poids des véhicules vides (colonne J) et pleins (colonne K). Les valeurs introduites dans ces colonnes ont été définies par les limites de charge des catégories lorsqu'elles

existent et sont estimées à partir de renseignements obtenus auprès d'une entreprise de transport dans les autres cas. Il s'agit là d'une valeur d'expert.

La colonne G compare les valeurs moyennes du poids des véhicules de chaque catégorie avec celles obtenues à partir des pesages WIM. Les nombres d'essieux équivalents pour chaque catégorie de véhicules sont alors calculés dans la colonne L en sommant les résultats des essieux qui composent le véhicule et en multipliant cette somme par le rapport des charges moyennes élevés à la puissance 4. Reste alors à diviser les résultats de la colonne L (nombre d'essieux équivalents) par la charge utile moyenne des véhicules (colonne D moins colonne J). Il convient encore de préciser que dans le cas des bus, le nombre d'essieux équivalents est divisé par la charge utile maximale admissible (colonne K moins colonne J).

Les **Afp sont obtenus de façon similaire** en mettant la puissance égale à 1 et sans effectuer la division par la charge.

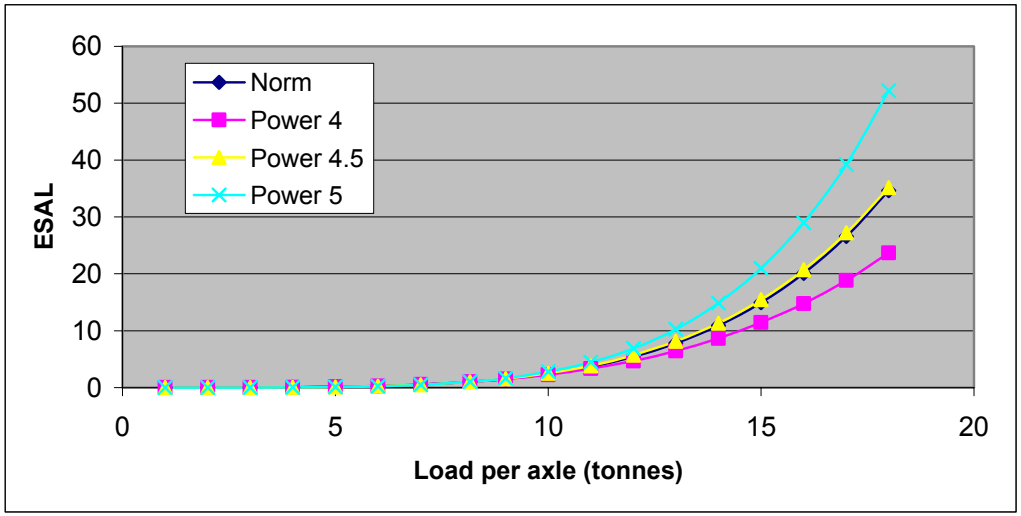
Written by **Jacques Perret**, March 21, 2005, dr ès sc., ing civil EPFL, Conseils en Génie civil, Ch. des Triaudes 8, CH-1024 Ecublens (VD), e-mail : nibuxs@urbanet.ch

**See separately:**

Dumont, A-G, Perret, J, and Torday, A: "Compte routier – vérification des coefficients de répartition des coûts," Laboratoire des voies de circulation, Département de Génie Civil, École Polytechnique Fédérale de Lausanne, October 2000 (in French).

## Annex CH-14.2 : Approximation ESAL

| tonnes | Norm | Power 4 | Power 4.5 | Power 5 |
|---|---|---|---|---|
| 1 | 0.0005 | 0.0002 | 0.0001 | 0.0000 |
| 2 | 0.006 | 0.004 | 0.002 | 0.001 |
| 3 | 0.02 | 0.02 | 0.01 | 0.01 |
| 4 | 0.07 | 0.06 | 0.04 | 0.03 |
| 5 | 0.15 | 0.14 | 0.11 | 0.09 |
| 6 | 0.29 | 0.29 | 0.25 | 0.21 |
| 7 | 0.53 | 0.54 | 0.50 | 0.46 |
| 8.16 | 1 | 1 | 1 | 1 |
| 9 | 1.52 | 1.48 | 1.55 | 1.63 |
| 10 | 2.40 | 2.26 | 2.50 | 2.76 |
| 11 | 3.66 | 3.30 | 3.83 | 4.45 |
| 12 | 5.40 | 4.68 | 5.67 | 6.88 |
| 13 | 7.76 | 6.44 | 8.13 | 10.26 |
| 14 | 10.87 | 8.66 | 11.35 | 14.87 |
| 15 | 14.91 | 11.42 | 15.48 | 20.99 |
| 16 | 20.06 | 14.78 | 20.70 | 28.98 |
| 17 | 26.54 | 18.84 | 27.19 | 39.25 |
| 18 | 34.59 | 23.68 | 35.17 | 52.23 |



## Annex CH-14.3 : Afe for OFS

| Type of axle | | | Single axle | | | Tandem axle | | | | Tridem axle | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Designation | | | ESi8t | ESi10t | ESi12t | ETa10t | ETa12t | ETa16t | ETa18t | ETr12t | ETr24t | Power: | 4 |
| ESAL | | | 0.0673 | 0.8986 | 1.1571 | 0.2566 | 0.3781 | 1.0498 | 1.6182 | 0.3642 | 0.5701 | | |
| Average | | | 2.1912 | 5.6052 | 5.9008 | 7.5193 | 7.3298 | 10.3316 | 11.2025 | 10.1546 | 11.6741 | | |
| Maximum | | | 8 | 10 | 12 | 10 | 12 | 16 | 18 | 12 | 24 | | |
| Empty | | | 1.5 | 2 | 2.5 | 3 | 3 | 3.5 | 3 | 3 | 4 | | |

| | | | Av. cat | Av E1 | Av E2 | % E1 | ESAL E1 | ESAL E2 | Empty | Max | ESAL | CA | WIM | CR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Public Coaches/Buses** | ESi10t | ESi12t | 14.75 | 5.6 | 5.9 | 128.2% | 0.899 | 1.157 | 11.5 | 18 | 5.552 | ***0.854*** | 0.16 | 0.556 |
| **Private Coaches** | ESi10t | ESi12t | 14.75 | 5.6 | 5.9 | 128.2% | 0.899 | 1.157 | 11.5 | 18 | 5.552 | ***0.854*** | 0.04 | 0.539 |
| Trucks: | | | | | | | | | | | | | | |
| **2-Axles (3501-5000)** | ESi8t | ESi10t | 4.25 | 2.2 | 5.6 | 54.5% | 0.067 | 0.899 | 3.5 | 5 | 0.085 | **0.114** | 0.04 | 0.022 |
| **2-Axles (5001-9000)** | ESi10t | ESi12t | 7.00 | 5.6 | 5.9 | 60.8% | 0.899 | 1.157 | 5 | 9 | 0.282 | **0.141** | 0.16 | 0.08 |
| **2-Axles (9001-13000)** | ESi10t | ESi12t | 10.75 | 5.6 | 5.9 | 93.4% | 0.899 | 1.157 | 8.5 | 13 | 1.566 | **0.696** | 0.62 | 0.233 |
| **2-Axles (+13000)** | ESi10t | ESi12t | 13.50 | 5.6 | 5.9 | 117.3% | 0.899 | 1.157 | 9 | 18 | 3.896 | **0.866** | 1.72 | 0.579 |
| **3-Axles (13000-16000)** | ESi10t | ETa16t | 13.25 | 5.6 | 10.3 | 83.1% | 0.899 | 1.050 | 10.5 | 16 | 0.931 | **0.339** | 0.40 | 0.645 |
| **3-Axles (+16000)** | ESi10t | ETa18t | 18.25 | 5.6 | 11.2 | 108.6% | 0.899 | 1.618 | 11.5 | 25 | 3.498 | **0.518** | 1.13 | 0.645 |
| **4-Axles (+25000)** | ETa16t | ETa18t | 20.75 | 10.3 | 11.2 | 96.4% | 1.050 | 1.618 | 13.5 | 28 | 2.300 | **0.317** | 0.65 | 0.529 |
| Trailers: | | | | | | | | | | | | | | |
| **Light** | ESi8t | | 2.25 | 2.2 | 0.0 | 102.7% | 0.067 | 0.000 | 1 | 3.5 | 0.075 | **0.060** | 0.05 | 0.042 |
| **1-Axle (3501-10000)** | ESi10t | | 6.00 | 5.6 | 0.0 | 107.0% | 0.899 | 0.000 | 2 | 10 | 1.180 | **0.295** | 2.84 | 0.042 |
| **2-Axles (up to 10000)** | ESi8t | ESi8t | 6.50 | 2.2 | 2.2 | 148.3% | 0.067 | 0.067 | 3 | 10 | 0.651 | **0.186** | 0.02 | 0.042 |
| **2-Axles (+10000)** | ESi10t | ESi12t | 10.25 | 5.6 | 5.9 | 89.1% | 0.899 | 1.157 | 3.5 | 17 | 1.295 | **0.192** | 1.74 | 0.042 |
| **3-Axles (+10000)** | ESi10t | ETa16t | 14.43 | 5.6 | 10.3 | 90.5% | 0.899 | 1.050 | 4.85 | 24 | 1.308 | **0.137** | 0.86 | 0.042 |
| Tractor for semi-trailer: | | | | | | | | | | | | | | |
| **2-Axles (up to 3500)** | ESi8t | ESi8t | 2.25 | 2.2 | 2.2 | 51.3% | 0.067 | 0.067 | 1 | 3.5 | 0.009 | **0.007** | 0.01 | 0.015 |
| **2-Axles (3501-13000)** | ESi8t | ESi10t | 8.25 | 2.2 | 5.6 | 105.8% | 0.067 | 0.899 | 3.5 | 13 | 1.211 | **0.255** | 0.29 | 0.161 |
| **2-Axles (+13000)** | ESi10t | ESi12t | 12.30 | 5.6 | 5.9 | 106.9% | 0.899 | 1.157 | 6.6 | 18 | 2.685 | **0.471** | 2.32 | 0.518 |
| **3-Axles (+13000)** | ESi10t | ETa16t | 17.45 | 5.6 | 10.3 | 109.5% | 0.899 | 1.050 | 8.9 | 26 | 2.800 | **0.328** | 1.20 | 0.478 |
| Semi-trailer: | | | | | | | | | | | | | | |
| **1-Axle (up to 5000)** | ESi8t | | 3.00 | 2.2 | 0.0 | 136.9% | 0.067 | 0.000 | 1 | 5 | 0.236 | **0.118** | 0.14 | 0.14 |
| **1-Axle (+5000)** | ESi10t | | 6.50 | 5.6 | 0.0 | 116.0% | 0.899 | 0.000 | 3 | 10 | 1.625 | **0.464** | 0.87 | 0.14 |
| **2-Axles (up to 15000)** | ETa16t | | 10.00 | 10.3 | 0.0 | 96.8% | 1.050 | 0.000 | 5 | 15 | 0.921 | **0.184** | 0.08 | 0.14 |
| **2-Axles (+15000)** | ETa18t | | 13.75 | 11.2 | 0.0 | 122.7% | 1.618 | 0.000 | 5.5 | 22 | 3.673 | **0.445** | 0.63 | 0.14 |
| **3-Axles (+15000)** | ETr24t | | 14.00 | 11.7 | 0.0 | 119.9% | 0.570 | 0.000 | 6 | 22 | 1.179 | **0.147** | 0.35 | 0.14 |