

# Approaches for Establishing In-Use Vehicle Stock and Vehicle Mileages

Background Paper  
August 2017

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## The Project Context

The project Advancing Transport Climate Strategies in Rapidly Motorising Countries (TraCS) is implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and funded by the International Climate Initiative of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU).

Its objective is to enable policy makers in partner countries (Vietnam and Kenya) to specify the contribution of the transport sector to the mitigation targets of the Nationally Determined Contributions (NDCs). In addition, detailed knowledge on mitigation potentials can lead to raising the level of countries' ambitions.

The project follows a multi-level approach:

- At country level, TraCS supports transport ministries and other relevant authorities in systematically assessing GHG emissions in the transport sector. This includes the collection and processing of transport data, as well as calculating emission reduction potentials through the development of scenarios.
- At international level, TraCS organises an active exchange between implementing partners, technical experts and donor organisations to enhance methodological coherence in emission quantification in the transport sector (South-South and South-North dialogue). The dialogue aims to internationally increase transparency regarding emission mitigation potentials and harmonisation of methodological approaches in the transport sector.

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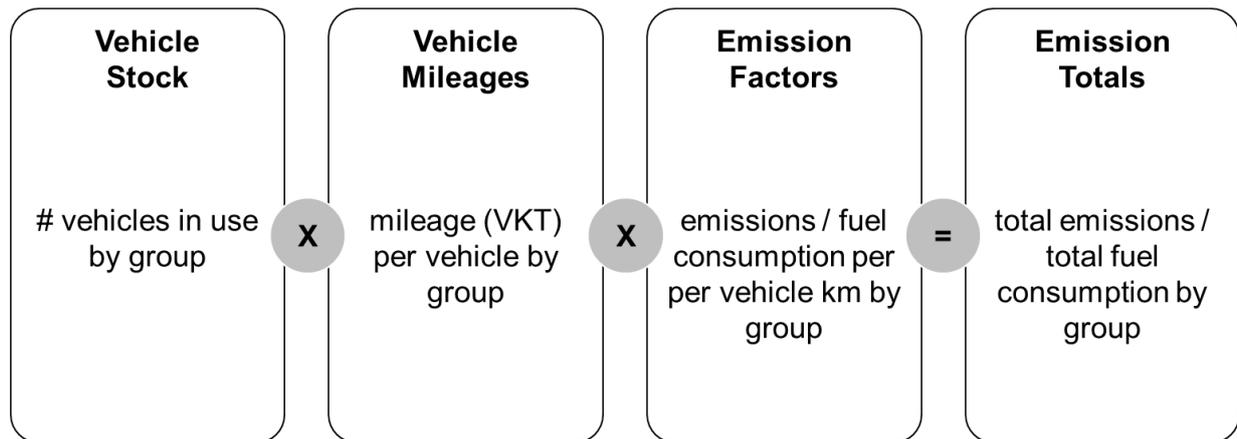
## Glossary

BAST	German Federal Highway Research Institute (Bundesanstalt für Straßenwesen)
BMUB	Federal Ministry of the Environment (Bundesumweltministerium)
BMVI	Federal Ministry of Transport (Bundesverkehrsministerium)
DLR	German Aerospace Center, (Deutsches Zentrum für Luft- und Raumfahrt)
FLE	German Vehicle Mileage Survey (Fahrleistungserhebung)
GDV	German Insurance Association
HU	Vehicle inspections / vehicle roadworthiness tests (Hauptuntersuchung)
KBA	German Federal Motor Transport Authority (Kraftfahrtbundesamt)
KiD	Vehicle User Survey (Kraftfahrzeugverkehr in Deutschland)
MiD	Travel Survey „Mobility in Germany“ (Mobilität in Deutschland)
MOP	German Mobility Panel (Mobilitätspanel)
MTPL	Motor Third-Party Liability
NTS	National Travel Survey
PTI	Periodical technical inspections
TREMODO	Transport Emissions Modell (German bottom-up transport emissions inventory)
UBA	Federal Environment Agency (Umweltbundesamt)
ViZ	National Transport Statistics (Verkehr in Zahlen)
VKT	Vehicle Kilometers Travelled (= vehicle mileage)
ZFZR	German Federal Vehicle Register (Zentrales Fahrzeugregister)

# 1 Introduction

Reliable data on the number of vehicles in use by vehicle type and on vehicle mileage form an essential input for a bottom-up emissions inventory for transport (Figure 1). This background paper covers approaches which serve to establish vehicle mileage. In addition, the paper presents methods applied in Germany, USA and France to obtain an up-to-date vehicle register. Hence, the paper deals with the first two of the three main components for establishing a bottom-up emissions inventory.

The focus of the methods discussed in this paper is the passenger car. Special attention is given to the applicability of the presented approaches to two-wheelers. The objective of this paper is to discuss the methods, their strengths and weaknesses as well as the context of the different approaches. This will help identifying approaches which are suitable for application in different contexts, for example in Vietnam.



**Figure 1: Component of a bottom-up emissions inventory.**

The paper begins with an overview over the institutions involved in establishing vehicle mileages in Germany. Thereafter, we will present the approaches used in Germany, France and USA to maintain the vehicle register and continue to show the different approaches to assess VKT<sup>1</sup>. Finally, this paper presents options to establish vehicle stock VKT statistics in Vietnam as discussed in the workshop in Serena Resort on July 12 and 13.

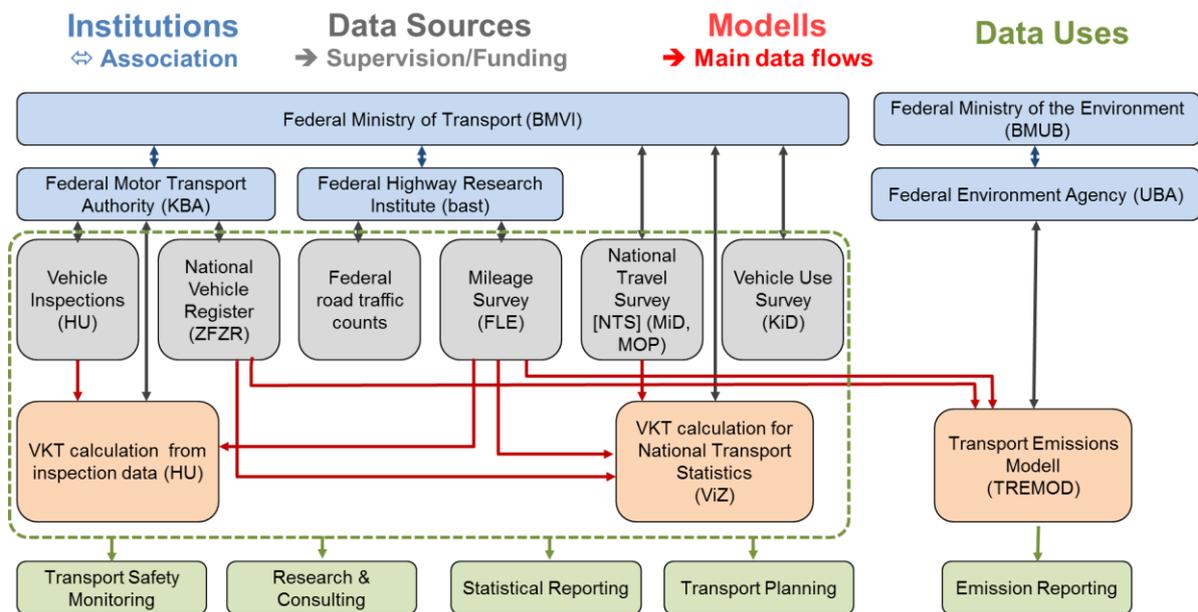
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<sup>1</sup> VKT stands for vehicle kilometers travelled; in this paper the terms mileage and VKT are used synonymical.

## 2 Institutional Overview

The German system of registering vehicles and generating VKT information is almost exclusively under the responsibility of the Federal Ministry of Transport (BMVI). The BMVI and its associated organizations supervise and fund (if applicable) the different approaches. Figure 2 illustrates this with focus on data on passenger cars and two-wheelers. There are additional data sources for truck VKT and goods transport which are not part of this paper.

The Federal Ministry of the Environment (BMUB) and the Federal Environment Agency (UBA) are users of the generated data on vehicle stock and VKT in the context of emission monitoring and reporting: UBA supervises and contracts the TREMOD-Modell which is the central tool for generating a bottom-up emissions inventory. TREMOD uses data generated by the BMVI and its organizations (Wolfram Knörr, 2014).



**Figure 2: Institutional set-up and context of the different data sources on vehicle stock and VKT in Germany**

Three of the data sources relevant in this context are under direct supervision of BMVI: The National Travel Surveys MOP and MiD, the Vehicle Use Survey KiD and the National Transport Statistics (ViZ) are subject to calls for tender and contracted by BMVI (infas & DLR, 2010b; Vortisch et al., 2012; Wermuth et al., 2012). The Mileage Survey (FLE) is under supervision, tendered and contracted by the Federal Highway Research Institute (BAST) (Bäumer et al., 2017a). Contractors for these activities are usually combinations of scientific institutions and, if needed, field work/market research companies.

The other activities to establish the relevant data (vehicle inspections, vehicle register, federal road traffic counts and VKT calculations from inspection data) are under direct supervision or are even carried out by the institutions associated with the BMVI (Fitschen & Nordmann, 2016).

In particular with regard to establishing VKT, Germany uses different methods. The reason is that they all have their advantages and disadvantages, ranging from cost issues to methodological issues. In order to generate reliable annual data on VKT all these different methods are combined. Hence, there is a strong linkage between the different methods as exemplified by the red links in Figure 2 which show the main data flows.

The data generated by these different instruments goes far beyond vehicle stock and vehicle mileage information. Examples for additional important statistics include:

- Information on availability of cars, licenses, motorized two-wheelers and bicycles in private households and on the person level;
- Information on total travel demand, i.e. the number of trips generated by the population including all modes of travel;
- Information on travel demand by purpose (e.g. work, shopping, leisure);
- Information on mileages with non-motorized modes;
- Information on the mode shares of different modes of travel.

This is to illustrate that the statistical system for transport in Germany does not only serve to generate data on vehicle stock and VKT. Instead, vehicle stock and VKT data are just one output of a broad range of statistical data which serves a broad variety of needs.

The BMVI is one of the main users of the data generated by this statistical system. Most important BMVI usages of the data include federal transport planning, transport safety monitoring as well as consulting to political decision makers.

However, the data generated by BMVI and its institutions are also made available to the public. Hence, also the industry or private consultancies use the data for a broad variety of purposes. Mostly, these users use aggregate statistics such as the National Transport Statistics ViZ. However, in some cases users also acquire the actual data sets (e.g. survey data sets) and perform statistical analyses using the data.

In short, the data generated by the system illustrated in Figure 2 goes much beyond vehicle stock and VKT data and serves a broad variety of users and purposes.

## 3 Approaches for Establishing In-Use Vehicle Stock

This section covers approaches for generating statistics on the national stock of in-use vehicles. The basis for such statistic is usually the vehicle register. Hence, the idea is to maintain the vehicle register such that it contains only vehicles which are in use. In this paper, we focus on Germany, France and USA which have different mechanisms in place to keep their vehicle registers up-to-date<sup>2</sup>.

However, there are also additional sources of information to obtain information on the in-use vehicle stock. These are covered in section 3.5.

### 3.1 Basic Concept of up-to-date Vehicle Registers

In all three study countries the basic concept of vehicle registrations is similar:

- Newly registered vehicles have a unique vehicle id; with this vehicle id they enter into a vehicle register data base.
- Whenever the vehicle changes the owner, is scrapped or sold abroad there is an official transaction in the register or a de-registration takes place.
- As a result, there should always be an up-to-date register; this means vehicles in the register should be linked to the correct owner information and there should not be vehicles in the register which are not in use any more.

In reality, however, there are conditions which result in vehicle registers not being up-to-date. There are two main reasons for this:

- Central or federal vehicle registers are usually a combination of decentral or local registers. The process of combining information from decentral registers into the central register can go along with time delay and loss of information.
- Some vehicle transactions (e.g. vehicle being sold abroad, scrapping of vehicle) might not go along with corresponding transactions in the vehicle register. Reasons for this are that vehicle owners do not trigger the associated process in the vehicle register, e.g. because they don't see a reason to do so (e.g. if they just abandon the vehicle).

These factors which result in divergence of vehicle registers and the vehicle stock in use are different in Germany, France and USA. These realities and the associated approaches to address these issues will be presented next on a country by country basis.

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<sup>2</sup> The information compiled in this section has been retrieved through personal communication with various experts in the respective countries. The authors are not aware of official publications that document the presented processes and facts. Hence, no references are provided for this section.

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## 3.2 Vehicle Register Situation in Germany

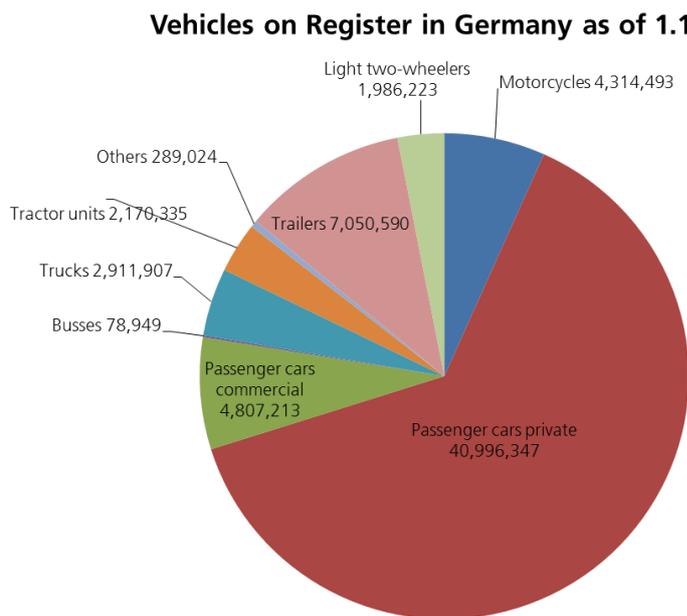
The relevant vehicle registration offices / institutions in Germany (about 400) are located on the county level. Hence, new vehicle registrations and all transactions in the vehicle register initially take place on the county level. The county level vehicle register data bases are combined into a federal vehicle register data base which is updated continuously as changes in local registers take place. Hence, there exists a federal data base with individual vehicle entries, identified by the unique vehicle id.

German vehicle owners pay an annual tax. In addition, each vehicle has to be insured and insurance is linked to the vehicle register (only insured vehicles can enter into the register and have a valid license plate). Vehicle tax and vehicle insurance are pre-paid for one year. If a car is sold or scrapped before the year has passed, the owner is reimbursed the amount for the corresponding missing number of months. Due to this system, vehicle owners in Germany are incentivized to de-register their vehicle if they don't use it anymore. Otherwise they will lose money.

As a consequence of this, the German vehicle register is relatively up-to-date. However, there might be vehicles in the register which are not used anymore but still have a valid number plate if the owner does not care for the annual costs.

This mechanism applies to all motor vehicles in Germany with the exception of light motorized two-wheelers. Such two-wheelers have a number plate; however, owners do not have to register these vehicles at the county registration office. Instead they purchase the required insurance every year directly from an insurance company. They are given number plate from the insurance and the insurance transmits the information directly to the federal vehicle register.

In order to illustrate the situation of the vehicle stock in Germany which underlies the VKT figures discussed later on, we show the number of vehicles on register in Figure 1.



**Figure 3: Vehicle stock in Germany as of 1.1.2017 (Kraftfahrtbundesamt, 2017)**

### 3.3 Vehicle Register Situation in USA

In the USA, vehicle registrations and transactions in the vehicle register also take place on the county level. The county level vehicle register data bases are combined into a state vehicle register data base. However, unlike in Germany a federal register does not exist as states only transmit aggregate tables to the federal level.

In addition, the vehicle register situation strongly varies across US states as do annual taxes and registration fees. In some cases vehicle owners do not trigger the official transaction in the vehicle register if they scrap or abandon the vehicle or move to another state. However, it is unclear how often this occurs and this varies from state to state.

The annual or bi-annual re-registration of vehicles which is required by the states offers a solution to this problem. Only with this re-registration vehicle owners obtain a windshield or license plate sticker which indicates that the vehicle is registered. (The possibility to link regular vehicle inspections with the vehicle register does not exist; see France).

However, problems remain: Because scrapping or selling the vehicle abroad etc. can occur in-between re-registrations, the vehicle register is not completely up-to-date but it always lags regarding registrations and de-registrations to an unknown extent.

## 3.4 Vehicle Register Situation in France

In France, vehicle owners don't pay an annual tax and insurance is not linked to the vehicle register. As a consequence, owners may not be motivated to trigger the official transaction or deregistration when stopping to use the vehicle. Some do but others don't. For example, owners may just abandon their vehicle, sell it abroad or let it rust on the shed without deregistering it. As a result, it is unclear how many vehicles there are still in the French vehicle register that are not used anymore. Based on survey results, however, it is clear that this problem is worse for two-wheelers than for cars. This is also intuitive as it is more likely to simply stop using a two-wheeler without officially de-registering it than a car.

Up-to-now the pragmatic solution for official vehicle statistics was to exclude vehicles older than 15 years from the official figures. Currently, however, there is a trial project underway which aims at generating more up-to-date statistics: The idea is to match vehicle IDs of vehicles that come to vehicle inspection (every 2 years from age 4 onward) with the register and remove vehicle that don't show up for testing. This offers a solution, but again there might be delay because owners might stop using vehicles before the two-year period ends. Moreover, this solution will not work for two-wheelers as for two-wheelers there is no requirement of vehicle inspection.

## 3.5 Additional Options to Source Vehicle Fleet Data

In addition to vehicle registers, motor insurance data and vehicle tax data can provide information on the number of in-use vehicles per country. These sources of information are presented in the following with a focus on the situation in Germany and Europe.

### 3.5.1 Vehicle fleet numbers: motor insurance information

The EU Motor Insurance Directive (2009/103/EC) requires all vehicles to be covered for motor third-party liability (MTPL) up to a minimum amount for both bodily injury and physical damage (European Union, 2009). In addition to MPTL cover, optional motor insurance — often known simply as “damage cover” — can be purchased. This covers, for example, damage caused to an insured vehicle by the insured (first-party loss), by external events (e.g. natural disasters or fire) or by third parties (e.g. theft or vandalism).

Insurance companies keep records of the number of liability insurance policies issued for vehicles. The object insured should normally be the vehicle, while the policy holder is a person or a company. Thus the corresponding record for each liability insurance contract will contain information on the policy holder (e.g. address) and on the vehicle (e.g. make, model, age, power). The technical information on the vehicle will depend inter alia on the terms on which the premium is calculated (pricing of insurance policies). These terms will vary over vehicle types, therefore also the technical information may vary accordingly.

In Germany individual insurance companies provide data on the vehicle liability insurance status to the German Insurance Association (GDV), where this information is compiled and checked against the vehicle fleet statistics of the Federal Motor Transport Authority (Kraftfahrt Bundesamt KBA). This comparison yields satisfactory results. On this national level there may be some technical details for the vehicles that is reported uniformly by the insurance companies.

The GDV in turn reports aggregated statistics on the insurance market to the European Insurance and Reinsurance Federation. Here, the data on motor insurance is used among other issues for comparative market analysis and for estimation of the size of the European fleet of vehicles in use (Insurance Europe, 2015).

#### 3.5.2 Vehicle fleet numbers: taxation record information

Countries may apply different kinds of taxation on vehicles:

- one-off duties related to the purchase and registration of vehicles (value added tax, registration tax, registration fees),
- duties imposed periodically in relation to ownership and tenure of vehicles (road tax, insurance tax),
- duties that arise in relation to the use of vehicles (energy tax, CO<sub>2</sub>-tax, value added tax).

Depending on the type of vehicle, compulsory taxation of the first or second form may be defined by the tax code and an appropriate tax administration will collect and monitor the tax receipts. The information on the vehicles handled by the tax administration should include those technical details of the vehicles that are factors for the assessment of the tax (e.g. type of vehicle, weight, age, power, etc.).

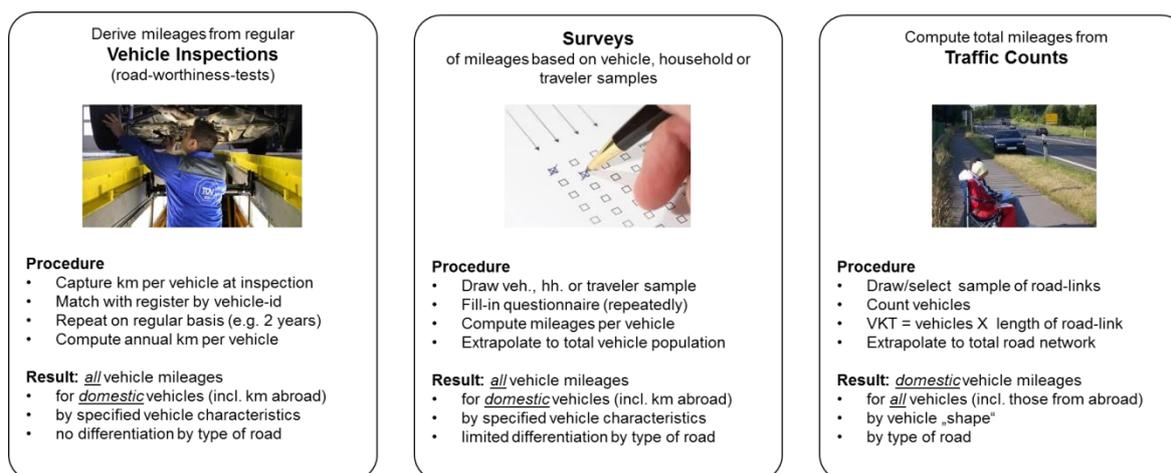
In Germany the compulsory annual road tax is a federal tax and is managed by the customs administration. Regional customs offices handle the collection and administration of the taxation process and submit results to the Federal Ministry of Finance. Here, total tax receipts are evaluated and the numbers of vehicles taxed are aggregated. The total numbers by vehicle types coincide well with the total registration as recorded by KBA.

## 4 Approaches for Establishing Vehicle Mileages

This section presents approaches for establishing vehicle mileage covering *empirical sources* such as surveys as well as *modelling approaches*. All of these approaches have strengths and weaknesses as discussed below. In addition, they differ in the definition of vehicle mileage which they are able to deliver. Important differences in definition relate to the

- population of vehicles covered: exclusively domestic vehicles versus also including foreign vehicles and the
- geographic area covered: exclusively mileage on domestic territory versus also including mileage abroad.

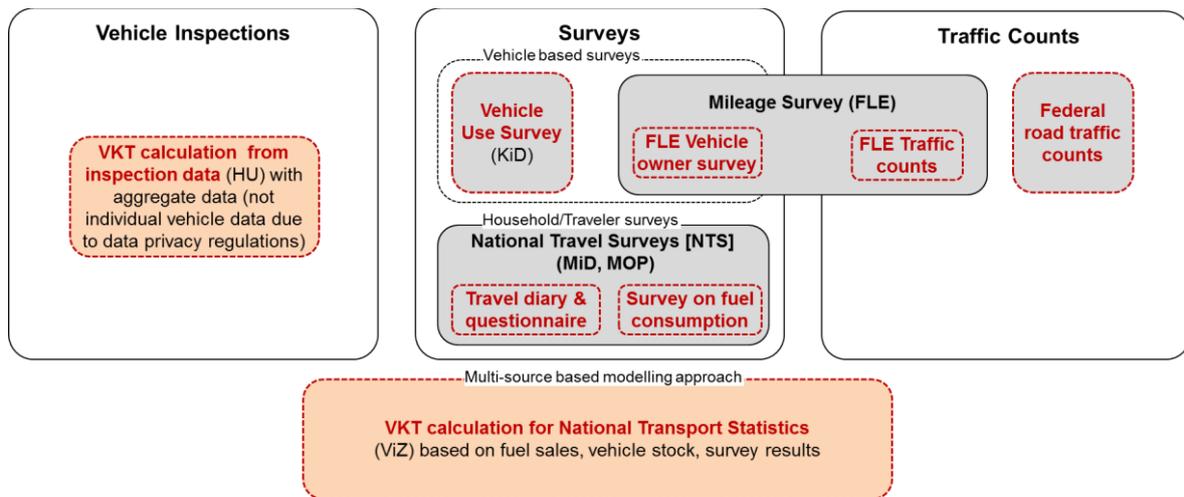
As for empirical approaches to elicit data on vehicle mileages there are three basic approaches as depicted in Figure 4. In principle, vehicle mileages can be derived from regular vehicle inspections, from surveys and from traffic counts. Figure 4 also shows which kind of definition of the result applies to the different methods.



**Figure 4: Basic empirical approaches for establishing vehicle mileages**

In Germany, all of these possible data sources are utilized to some extent (Figure 5). However, the method of deriving mileages from vehicle inspections in Germany differs from the original idea as depicted in Figure 4. Instead, the data from vehicle inspections is combined in a model. An additional modelling approach is the VKT calculation for the National Transport Statistic ViZ. These calculations draw on multiple statistical sources and survey data.

Taken together there are eight methods in place which help to establish vehicle mileages in Germany on an annual basis and to monitor the development of mileages regularly. These eight methods are depicted (red frame) in Figure 5; approaches that involve modelling are identified by a orange box (orange background color).



**Figure 5: Categorization and Overview of German approaches for establishing vehicle mileages**

This raises the question why there are so many approaches available for establishing vehicle mileages in Germany. There are two main answers to this:

1. Some of these approaches serve a different main purpose (e.g. the NTS surveys). The fact that they deliver information on mileages is just a positive additional benefit. In order to have reliable information on vehicle mileages there are also dedicated approaches which focus on mileages.
2. Some of these approaches deliver information only on an irregular basis with multiple years in between (Figure 6). The reason for this is mainly the cost of large surveys. In order to have annual information on vehicle mileage, the various methods are combined.

Survey / Model	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
VKT calculation from inspection data																											
Vehicle use survey (KiD)																											
FLE vehicle owner survey																											
FLE traffic counts																											
Federal road traffic counts																											
NTS travel diary & questionnaire																											
NTS survey on fuel consumption																											
VKT calculation for National Transport Stats																											

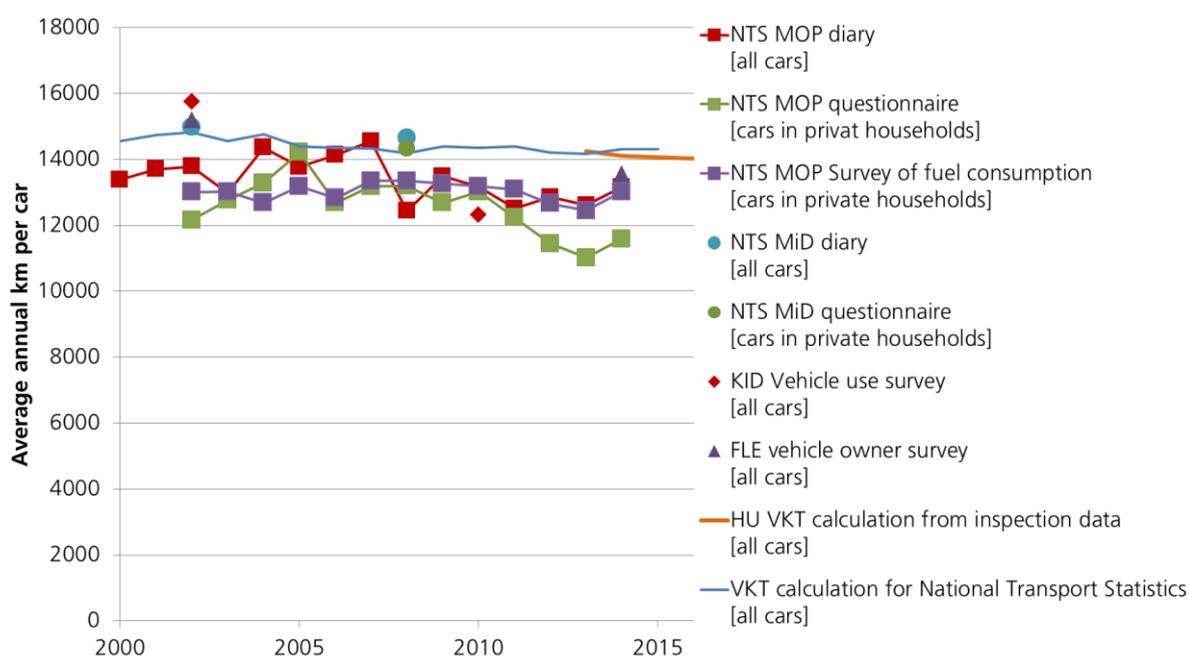
**Figure 6: Overview of data on vehicle mileage for every year since 1990 from different data sources**

Figure 7 shows the mileages per passenger and year as measured or modelled by the different approaches excluding traffic counts. The results of the different approaches differ

in detail. However, overall the results are quite similar and indicate that each approach results in the correct order of magnitude regarding the average annual passenger car mileages. Figure 7 will help to interpret the characteristics of the different approaches which will be presented in the next sections of the paper and their impact on the survey results.

As for the impact on survey results, Figure 7 in particular points to two issues:

- Surveys with small sample sizes (the NTS MOP survey series) produce much stronger variances across years and must be interpreted with greater care.
- The interpretation of the different results must consider which vehicles are covered by the respective approach: surveys that cover only cars in private households (e.g. NTS MOP Survey of fuel consumption) produce lower figures than those approaches that cover all cars, i.e. including passenger cars in use by commercial users. This is logical as commercial vehicles tend to have higher annual mileages.



**Figure 7: Annual passenger car mileages per car as measured or modelled by the different approaches applied in Germany since 2000**

Table 1 shows an overview over the type of information that the different approaches deliver. The three columns in the middle of the table refer to the important components for a bottom-up emissions inventory for transport as depicted in Figure 1. The rightmost column shows an additional dimension of output that specifically applies to the National Travel Surveys. Multimodal travel indicators (e.g. overall travel demand, modal split) are key for monitoring the development of transport across various modes.

The green color-coding in Table 1 also indicates the hierarchy or relevance of the different approaches in Germany. With regard to vehicle mileages, the FLE vehicle owner survey

(irregular) and the VKT calculations for the National Transport Statistics (annual up-dates) are the most important data sources. The other approaches mainly serve to validate the order of magnitude or trends.

	Vehicle Stock	Vehicle Mileages	Emission Factors	Multimodal Travel Indicators
Vehicle register, annual	Main source of data			
Vehicle use survey (KiD), irregular		Important source of empirical data		
Vehicle mileage from inspections (HU), annual		Important source of data		
FLE vehicle owner survey, irregular		Main source of empirical data		
FLE Traffic counts, irregular		Important source of empirical data		
Federal road traffic counts, annual		Useful source of empirical data		
NTS travel diary & questionnaire, irr./annual		Useful source of empirical data		Main source of empirical data
NTS survey on fuel consumption, annual		Important source of empirical data	Important source of empirical data	
VKT calculations for Nat. Transport Stats, annual		Main method of up-dating		

**Table 1: Type of information delivered by the different methods**

After this general introduction to the different approaches, their strengths and weaknesses and the results that they produce, we will next present the various approaches in detail in the following sections.

## 4.1 FLE Vehicle Owner Survey

This section covers the FLE Vehicle Owner Survey (Fahrleistungserhebung, Inländerfahrleistung) which represents the most important source of VKT data in Germany. A random sample is drawn from the national vehicle register including private and commercial registrations. Survey participants (in this case vehicle owners) report their odometer mileage at the beginning of the survey and the end of a ten-week period. This section includes a short description of the overall methodology applied in the German Vehicle Owner Survey 2014 on vehicle mileage (and changes compared to previous surveys, such as of 2002), including main challenges during the survey process and uncertainties in data collection (Bäumer et al., 2017a; Hautzinger, Stock, Mayer, Schmidt, & Heidemann, 2005).

### 4.1.1 Objective

There is general agreement that comprehensive data on motor vehicle kilometers travelled (VKT) with deep stratification can only be generated through special empirical studies with surveys of motor vehicle owners (national VKT) and traffic counts (domestic VKT) as core elements. In view of the associated costs, however, such studies are only conducted

at long intervals and thus have the character of occasional individual studies (“vehicle mileage surveys”).

To determine the national VKT, as part of the German Vehicle Mileage Surveys (FLEs) in 1990, 1993 and 2002, owner surveys were planned, evaluated, conducted, and analyzed under the auspices of German Federal Highway Research Institute (BASt), with the organizational/ technical execution of the written/postal surveys being handled by the Federal Motor Transport Authority (KBA). This involved surveying a random sample of vehicles across the entire year (sample frame: central vehicle register of the KBA) to determine the VKT through two odometer readings over a reporting period defined by the survey design.

The objective of the 2014 FLE vehicle owner survey was to provide current indicators on the national VKT that are comparable in terms of content and methodology with previous studies while simultaneously taking into account changes in vehicle types and vehicle usage that have occurred in the intervening period. It goes without saying that the study was intended not only to estimate the national VKT as a whole with the greatest possible precision, but also the VKT of particular sub-groups of German-registered vehicles as well. As the classification characteristics for the delineation of these sub-groups, the study looks not only at registration characteristics (technical vehicle characteristics and characteristics of the owner) but also survey characteristics that characterize the predominant use or type of use of the vehicle.

#### 4.1.2 Methodology

The 2014 vehicle owner survey to determine national VKT was largely identical to the preceding study in 2002. The survey again included all motor vehicle types, from mopeds to semi-trailers (only a few special motor vehicle sub-groups such as agricultural tractors and vehicles of the federal police and military are not recorded).

To determine the 2014 national VKT, over 6 survey waves of 151 motor vehicle strata each, a total of 162,650 vehicles were selected through systematic sampling from the central vehicle register (ZFZR) of the Federal Motor Transport Authority (KBA).

At the top level of a hierarchical system of stratification criteria the following 10 vehicle groups were distinguished:

- Motorcycles
- Passenger vehicles of private owners
- Passenger vehicles of business owners
- Buses
- Trucks of private owners
- Trucks of business owners
- Semi-trailers

- Other trucks
- Other vehicles
- Vehicle with insurance tag

The deeper stratification of the vehicle groups was made with regard to the following characteristics:

- the type of vehicle
- the age of the vehicle or the vehicle owner
- the engine power or mass of the vehicle
- the propulsion of the vehicle
- the economic sector of the vehicle owner (for business owners only)
- the number of seats (for buses only)

Within the 10 vehicle groups the breakdown by these characteristics was partly different due to group-specific constraints/reasons.

For example concerning the vehicle group “Motorcycles“ the characteristics

- type of vehicle (motorcycles, light motorcycles, scooters),
- age of the vehicle (with different age classes),
- engine power (with different engine power classes)
- propulsion of the vehicle (with the distinction between electric and non-electric motorcycles)

were used. In this context, it is worth mentioning that in Germany we have the precondition, that motorised bicycle, moped, light moped are classified under the vehicle group “Vehicle with insurance tag”.

Overall, the stratification of the sampling frame should be carried out with characteristics related to the vehicle kilometers travelled.

By surveying the respective vehicle owners with regard to the vehicle odometer readings on two key dates ten weeks apart, the study gathered data regarding the average daily mileage of the vehicles included in the study. In addition to the odometer reading on two occasions (called initial and final survey), the vehicle owner survey also collected information about some additional characteristics such as the predominant type of use of the vehicle and mileage driven outside Germany in foreign countries. These additional characteristics can not only be used to break down the total VKT, but can also be regarded as independent analysis variables.

With a response rate of 56 % in the initial survey and 85 % in the final survey, which amounted to a total response rate of approximately 47 %, a gratifyingly high degree of willingness to participate was found. Following the general trend, this rate was lower than in the preceding projects in 1990, 1993 and 2002, but mainly due to the newly developed mixed mode-design (extending the written-postal response option to an online variant; see

Figure 8) the result was actually somewhat above the target values defined prior to of the survey.

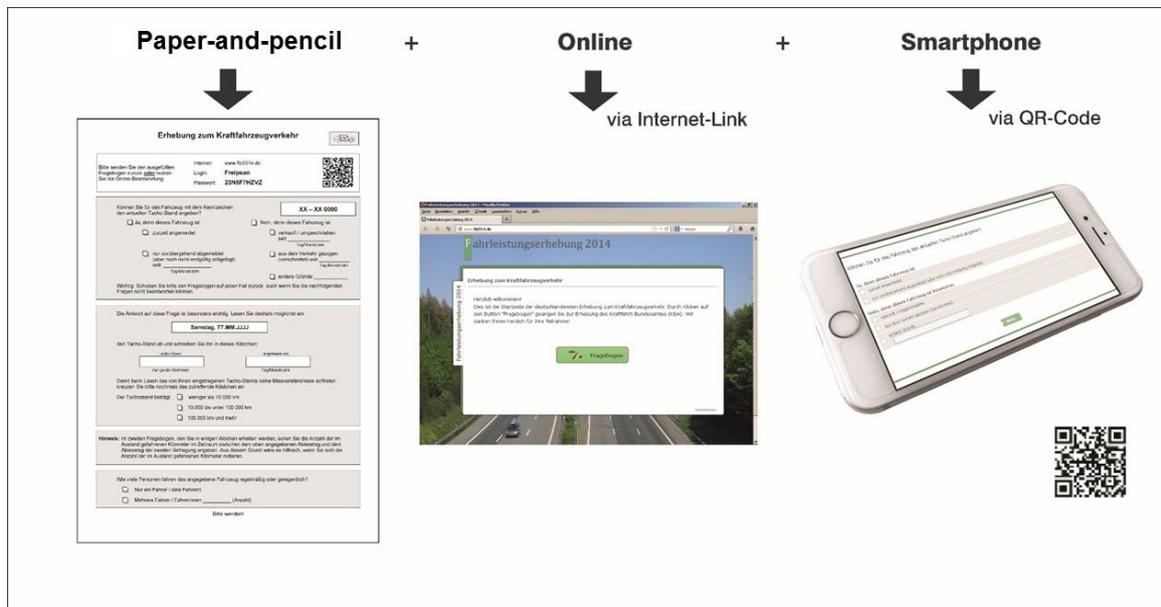


Figure 8: Response options in the FLE vehicle owner survey (mixed mode-design)

Based on the 2014 FLE owner survey, reference values and structural classifications of the total VKT were determined empirically according to the national concept. Due to the large size of the sample, it was possible to derive deeply stratified indicators both regarding the current state as well as – through comparison with the 2002 FLE – the development over time of VKT by vehicles registered in Germany. For the first time, it was also possible to collect useful VKT data for vehicles with alternative drive technologies and energy sources (electric, hybrid). The same applies to vehicles used in the context of new transportation options (e.g. long-distance buses).

The results obtained are based on the statistical method of separate ratio estimation for stratified samples (auxiliary variable: number of motor vehicle days registered). The starting point here is the aforementioned breakdown of the year under examination into 6 time periods and the vehicle population into 151 strata. For each time period and vehicle stratum, the VKT per vehicle and day of registration is estimated based on the sample data. Through multiplication by the population total number of motor vehicle days registered per period and vehicle stratum (calculation of this total is based on the ZFZR), estimated VKT figures for each time period and vehicle stratum can be derived. A summation over the periods yields the stratum-specific annual total VKT values, which in a final step can then be aggregated across individual strata (e.g. all passenger vehicle strata) or all strata of vehicles (motor vehicles altogether).

In the representation of the results, the total VKT in the study year is additionally related to the annual average number of registered vehicles. This ratio suggests itself since vehicles can fundamentally only generate VKT on days on which they are registered.

In the design-based estimation method of the 2014 FLE vehicle owner survey, the absolute and relative standard error of the estimator for the VKT can be determined with the aid of a specific estimation formula adapted to the sample selection and VKT estimation method actually applied. As such, the calculation of confidence intervals is possible at any time. The sampling error estimation can be conducted with standard statistical methods, not least due to the fact that neither the non-coverage nor the non-response study for the FLE vehicle owner survey yielded urgent necessities to correct for biases.

Concerning the results, the national VKT in 2014 came to roughly 707 billion vehicle kilometers travelled (with an average motor vehicle registration stock of 53.5 million vehicles). Table 2 shows the VKT per vehicle and year broken down by vehicle group.

Vehicle group	VKT per vehicle and year in km
Motorcycles	2,982
Passenger vehicles	13,568
Buses	51,309
Trucks	23,891
Semi-trailers	99,692
Other trucks	4,209
Other vehicles	11,921
Vehicle with ins. tag	2,532
Total	13,220

**Table 2: VKT per vehicle and year broken down by vehicle group (FLE 2014 vehicle owner survey)**

The tasks of the overall FLE 2014 project also included determining the “domestic VKT” (total of all motor vehicle kilometers travelled on the German road network, no matter where the vehicles are registered), which will be described in detail later. Thus, simultaneously with the vehicle owner survey, an automatic count of motor vehicle traffic at randomly chosen locations and days was also carried out. The 24-hour vehicle counts, yielding count data broken down by vehicle type and vehicle nationality, were distributed across the entire German road network and the entire year of 2014. The new primary survey (FLE traffic count 2014) provided the option for the first time in the present context to disaggregate indicators of the national VKT on the German road network by road class and location as well as by type of day and time of day.

The conceptual frame of the whole FLE 2014 project consisting of the vehicle owner survey and the vehicle counts can be summarized as follows:

Registration of vehicle	Territory of VKT		Total
	Domestic	Abroad	
Domestic	vehicle owner survey vehicle count	vehicle owner survey	vehicle owner survey
Abroad	vehicle count		
Total	vehicle count		

**Figure 9: Conceptual frame of the FLE 2014 project**

### 4.1.3 Methodological Evaluation and Outlook

It has proven useful to retain the basic concept of the previous FLE vehicle owner surveys (focus on the most important survey characteristics and use of a short, clearly structured and easily understandable questionnaire) and extend it to include the option of participating not only via post, but also electronically using a laptop, smartphone or like device (mixed-mode design). This made it possible to take account of the changed response behavior for public and corporate surveys and counteract the downward trend in willingness to participate in such surveys, as the high response rate of 47 % demonstrates.

Looking to the future of VKT statistics, it would appear that a further methodological innovation may soon aid work in this field as it becomes possible to use odometer-reading data for motor vehicles in two successive vehicle inspections that will shortly be available to the Federal Motor Transport Authority. The estimation of VKT on the basis of process data already available offers the opportunity to make the system of mileage surveys even more efficient in the future. The addition of vehicle inspection data would reduce the scope of the still-indispensable owner survey significantly.

## 4.2 FLE Traffic Counts

This section presents the traffic counts which were conducted in the context of the FLE in order to establish VKT of German and international vehicles on German territory (Fahrleistungserhebung Inlandsfahrleistung). This survey consists of automatic traffic counts which took place on randomly chosen roads sections in Germany. As opposed to the other approaches presented here, surveyed VKT also include mileage driven by foreigners on German territory (Bäumer et al., 2017b).

### 4.2.1 Objective

One significant indicator for transportation planning as well as emissions calculations is the annual total of domestic vehicle kilometers traveled (VKT), i.e. the sum of kilometers traveled by all motor vehicles (independent of their nationality) on the national road network in a year. Concepts for estimating VKT on the territory of the Federal Republic of Germany that were used in the past, such as border crossing surveys, are no longer applicable due to changes in the relevant legal context. The goal of the study was to estimate the domestic VKT - as an overall total and broken down by vehicle groups and subsegments of the road network - based on a nationwide traffic count conducted explicitly for this purpose. In particular, the study also aimed to enable a differentiation of kilometers traveled by the nationality of the vehicle.

Another objective of the study was to calculate accident risk indices based on the determined VKT values by relating the official road traffic accident figures of 2014 to the respective annual totals of vehicle kilometers traveled by motor vehicles on German roads. This includes the risk of a vehicle being involved in an accident involving personal injury as well as the risk of vehicles users being injured or killed in an accident.

### 4.2.2 Methodology

The traffic count conducted as part of the FLE 2014 was intended to provide

- results for all combinations of road class and location (within/outside built-up areas)

based from a methodological standpoint on a

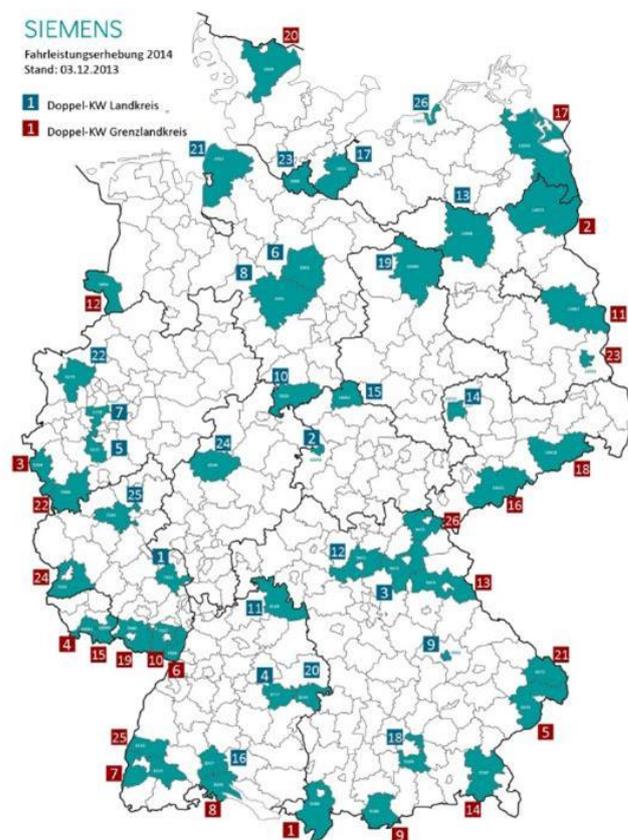
- random sample of locations and times of traffic observation.

Like the entire road network, the traffic count also aimed to cover the entire calendar year.

The prerequisite for conducting such a survey is an elaborated sampling concept in conjunction with a suitable frame for drawing a random sample of count locations. For the latter task, digital road network models, in which the entire road network can be broken down into numerous sections of equal length, were used. From this large universe of road sections (traffic direction sections), a random sample can be drawn where the section midpoints

represent the locations of the traffic counts. A total of 520 count locations and count days were selected.

As the study period encompasses an entire year and the count applies to the entire German road network, a simple random sample of locations and times would be expected to result in a strong spatial-temporal dispersion of the survey units and, associated with that, organizational problems and high survey costs. For this reason, a “territory-week sample” approach was selected. The approach involves a two-stage selection procedure in which at the first stage (primary selection) combinations of territory units and survey periods are selected. The national territory was divided into 402 districts (date: 12/31/2011) and the survey year into 26 two-week survey periods (“fortnights”). The selection units of the first stage (primary units) are therefore combinations of the type “district x fortnight.” To ensure coverage of the entire survey year, the primary selection was designed as a stratified sample, where district type (2 types) and sequence number of the fortnight (1-26) served as characteristics for stratification. Districts were categorized according to proximity to the German border (with/without border to other country). From each of the  $2 \times 26 = 52$  strata (i.e. per combination of district type and fortnight sequence number), 1 primary unit was selected randomly (52 independent drawings of 1 district-fortnight). The sample of primary units therefore consists of  $n=52$  district-fortnights (see Figure 10). The decision in favor of 1 primary unit per stratum was based on the idea that the study year should be covered evenly (fortnights) and that districts both far from and near borders should be adequately represented, but not least also on the fact that only 2 survey teams could be deployed simultaneously.



**Figure 10: Randomly selected primary units (districts) in the FLE 2014 vehicle count (source: Siemens AG)**

Within the selected primary unit, a random selection of "road section days", i.e. combinations of the type "road section x calendar day" (secondary selection) was then to be made. Here, the characteristics road class (federal motorway, federal road, state road, county road, other road) and location type (within/outside built-up areas) were used as the characteristics for stratification. Thus, within each primary unit, 9 strata of secondary units were formed. For each selected primary unit, a random selection of 1 road section day was made from each of the 9 strata of secondary units (on federal motorways 2 road section days). This resulted in a total sample of  $1 \times 2 + 8 \times 1 = 10$  road section days for each selected district-fortnight.

The counts were conducted by way of automated (multi-instrument) observation of the flowing traffic at the randomly selected locations (traffic direction sections) and days (number plate recording via video camera in conjunction with recording vehicle type (9 categories) via side or overhead radar detector). At each selected road section, the count was to continue over a period of (at least) 24 hours, where for organizational reasons the survey time interval did not necessarily have to be between midnight-midnight of the following day.

The sample expansion of the count data was done in three steps:

1. Expansion of the empirical vehicle kilometers traveled data (product of observed traffic volume and section length) – categorized by road class/location combinations – within the randomly selected district-fortnights (estimators at the second level: estimation of cluster total values of vehicle kilometers traveled based on individual empirical traffic volume and section length values).
2. Expansion of the estimation results for each selected district-fortnight - categorized by road class/location combinations - for the respective combination of district type and fortnight number (estimators at the first level: estimation of stratum total values of vehicle kilometers traveled based on estimated cluster total values).
3. Aggregation of the vehicle kilometers traveled estimates - categorized by road class/location combinations - across all combinations of district type and fortnight sequence number according to the statistical method of ratio estimation for stratified samples, where road section length serves as an auxiliary variable (estimation of overall total VKT values based on estimated cluster total values for the analysis variable and known stratum and overall total values for the auxiliary variable).

Moreover, in a final step of post-stratification, a structural adjustment was made to ensure that the sample distribution of the road section hours corresponded to the population distribution with regard to the characteristics type of weekday and hour-of-day interval.

To estimate error variances, a subsampling method (replicated subsampling due to DEMING) was used.

Regarding the results, the 2014 annual total domestic VKT is estimated to be 743.8 billion vehicle km. At 228.3 billion km, most of the kilometers were clocked on the federal motorway (Bundesautobahn or BAB) network; proportionally, this amounts to roughly 31 % of the total VKT. The total 2014 value for *vehicle kilometers traveled by foreign vehicles* on the German road network was approximately 42 billion vehicle kilometers.

The sample design of the FLE traffic count allows for temporal breakdowns of the VKT totals, in particular with regard to weekly and daily values. With regard to the *time of day*, i.e. the share of VKT occurring at a given hour of the day, results showed a slight traffic increase over the course of the day after the morning traffic peak. The maximum vehicle kilometers traveled were found to be between 4 pm and 6 pm in the afternoon (see Figure 11).

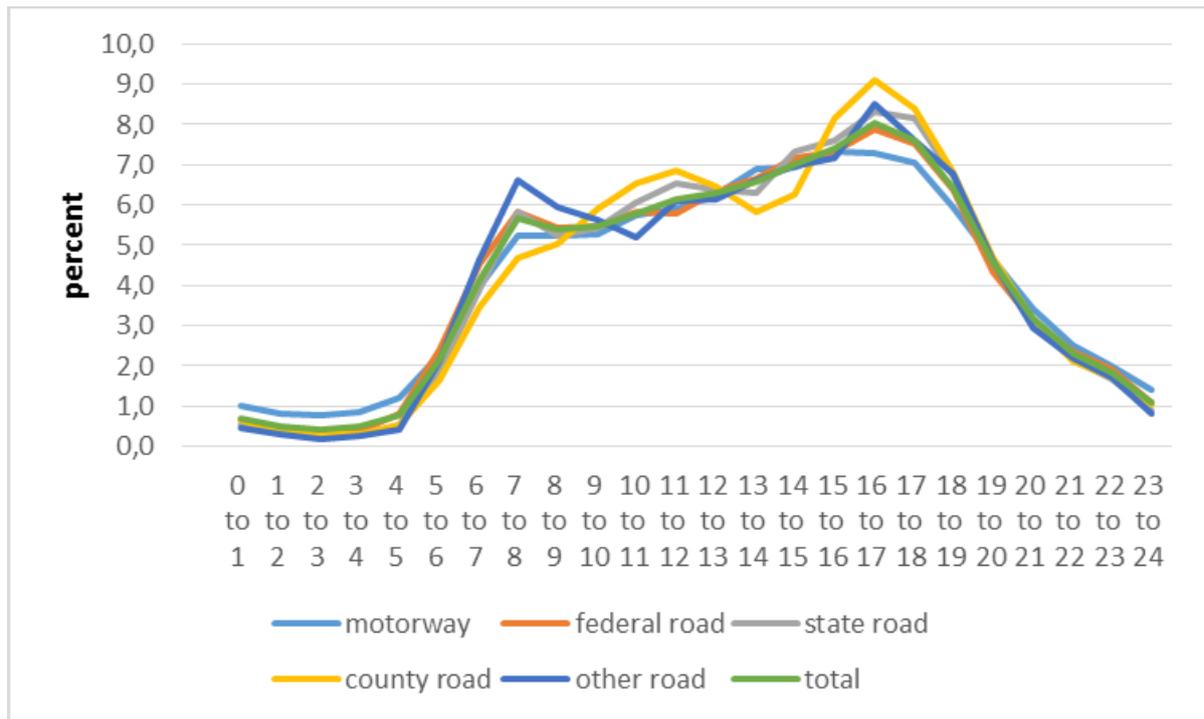


Figure 11: VKT shares by hour of day broken down by road class (FLE 2014 vehicle count)

### 4.2.3 Methodological Evaluation

The FLE traffic count to determine the vehicle kilometers traveled in 2014 represents the first comprehensive recording of transport activity on the road network of the Federal Republic of Germany. The survey includes all road classes and encompasses the totality of motorized traffic, i.e. all vehicle types. The survey also covers all times of day and year and distinguished vehicles with regard to their nationality.

From a statistical standpoint, it is notable that, in contrast to conventional traffic counts, the selection of survey locations (and times) was conducted according to a two-stage random sampling design. In constructing an appropriate sampling frame an innovative approach was developed: based on a digital road network model the entire road network was dissected into a very large number of short (100 meter) road sections; from a complete list of road sections derived from the digital road network model, the survey locations have been drawn.

It goes without saying that such an automated traffic count encompassing the whole country and covering a one-year period would generate substantial costs owing to the large-scale deployment of personnel and equipment. For this reason, the sample had to be restricted to 520 count locations, which certainly represented the minimum acceptable sample size with respect to the required precision of VKT estimates (relative standard error). Due to the small scope of the overall sample, at both selection stages just one unit (n=1) was

drawn for the vast majority of strata, which is clearly suboptimal for variance estimation. It would be advisable for other studies employing this design to choose a larger sample size wherever possible.

As concerns the survey methodology, the new multi-instrument approach presents the opportunity to conduct traffic counts “around the clock” with classification by vehicle type and nationality. But there is still room for improvement in terms of the recording accuracy (concerning the counting of motorized two-wheelers and the nationality of the vehicle) of the survey instruments.

### 4.3 Vehicle Mileage from Inspections

Vehicles have to pass official road worthiness tests on a regular basis. In this context, odometer mileages can be collected and used to estimate annual total mileages / VKT. This section describes how annual VKT are derived from vehicle inspections in Germany.

#### 4.3.1 Periodical Technical Inspections as a Source of Vehicle Mileage Data

Motorized vehicles have to pass official road worthiness tests (“periodical technical inspection”) on a regular basis. In this context, odometer readings can be collected and used in transport statistics to estimate total vehicle mileage, i.e. the sum of vehicle kilometers travelled by the vehicle population of interest during a specified time period.

Periodical technical inspections (PTI) are carried out by specialized technical service corporations offering vehicle inspection and exhaust tests. The due date of the periodical technical inspection is indicated in Germany by the round plate on the rear registration plate. The year is noted in the middle circle of the inspection plate, while the due month is always indicated by the number at the top edge of the inspection plate. There is no tolerance for exceeding the PTI deadline. The following applies to automobiles and motorcycles: the PTI is always due 24 months after the last inspection date. If an inspection plate expired more than two months ago, the technical service corporation has to conduct an in-depth inspection for which an additional charge is taken. The inspection will not be backdated.

If PTI test results together with appropriate concomitant vehicle characteristics (including type of vehicle and vehicle mileage as read from odometer) are made available for statistical purposes, estimation of vehicle mileage totals can be based on a huge amount of empirical data on vehicle use without conducting costly vehicle owner surveys .

#### 4.3.2 Basic Methodological Problems

In transport statistics, one normally aims to estimate the annual sum of vehicle kilometers, i.e. the total vehicle mileage per calendar year. Thus, the population to which the estimate

refers is the universe of vehicles registered in the current year. The sample, on which estimation is based, however, is the subpopulation of vehicles which had to undergo PTI during the current year. Obviously, in every year only part of the vehicle population has a positive chance of appearing in the sample. Moreover, the mileage at time of PTI corresponds to the overall number of kilometers travelled since first registration of the vehicle. Clearly, in our context data on the number of vehicle kilometers travelled during the current year would be more useful (see Section 4.3.4).

Against this background, several methodological questions have to be answered:

- Is it possible at all to estimate annual mileage totals based on a sample which contains no direct mileage information for the current year?
- Can year-to-year changes of mileage totals be estimated from odometer readings?
- May odometer readings and mileage information by period derived from it be transferred to vehicles which had not to pass PTI in the current year?

Subsequently, some methodological considerations are summarized.

### 4.3.3 Alternative Methodological Approaches

PTI-based estimation of annual vehicle mileage totals requires assumptions on the statistical relationship between vehicle kilometers travelled since first registration and kilometers travelled in the current year. In a corresponding Report, various possible methodological concepts have been investigated. For details see (Hautzinger, Fuchs, Schmidt, & Stock, 2010).

Among the candidate concepts *endogenous estimation based on cross-sectional data* proved to be most promising. Under this concept, the not observed mileage of vehicle  $i$  in the current year ( $y_i$ ) is approximated using information on vehicle mileage at time of PTI in kilometers ( $z_i$ ) and vehicle age at time of PTI in months ( $k_i$ ):

$$\hat{y}_i = T \cdot z_i / k_i \quad \text{where } T=12$$

The validity of this simplifying assumption has been tested empirically using data from a previous vehicle owner survey, where both per-day vehicle mileage since first registration and per-day vehicle mileage in the current year had been recorded. The model proved to be acceptable: temporal stability of vehicle mileage per day at the micro-level is not in contradiction to the well-known phenomenon at the aggregate level, where mean vehicle mileage decreases as age of vehicle increases (given constant mileage per day for individual vehicles, mean mileage is lower in higher vehicle age groups due to the fact that intensively used vehicles are dropping out of the vehicle stock earlier than less intensively used vehicles).

Not surprisingly, statistical estimation of annual vehicle mileage totals under the above concept needs careful data preparation and application of sampling theory. Among other

things, coverage problems have to be addressed and methods for improving estimation accuracy (such as poststratification) have to be applied.

#### 4.3.4 Concluding Remarks

Process data from periodical technical inspections can complement and improve vehicle mileage statistics based on vehicle owner surveys. If only the most recent odometer reading is retained, the estimated annual vehicle mileage total, however, may be biased by structural changes which occurred in the recent past. One can expect, for instance, that a sudden decrease in mean vehicle mileage due to sharply increasing fuel prizes will not be diagnosed correctly, but would rather be underestimated. Thus, estimation accuracy could be improved substantially, by providing not only the last but also the second to last odometer reading.

### 4.4 NTS Travel Diaries and Questionnaires

#### 4.4.1 The Concept of Travel Surveys Using a Travel Diary

The general idea of travel surveys is to elicit statistical data about travel with a much broader scope than just vehicle mileages. Travel surveys aim at capturing data about all types of passenger travel, i.e. including all modes and purposes. The core element of a travel survey is a travel diary (Figure 12). In this travel diary survey respondents record all their trips outside their home during a defined reporting period. This is usually one day, two days or one week.

The information reported for each individual trip includes

- Trip start time,
- Trip distance (e.g. self-estimated),
- Mode of travel (differentiating car driver and car passenger; possibly with information about the vehicle that has been used),
- Trip end time,
- Trip purpose/Activity at destination.

Travel diary surveys are the only data sources that provide a complete overview over travel demand and mode use. Thus, travel diary surveys are a key data source for most transportation planning and monitoring applications. In particular for travel demand modeling this data is indispensable.

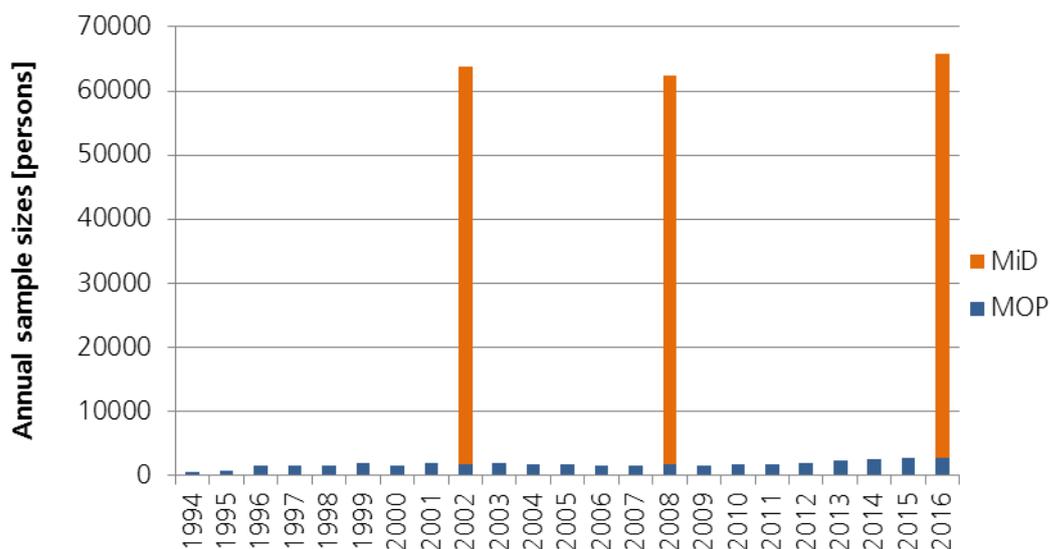
In addition to the travel diary, travel surveys consist of questionnaires that elicit information on the person and household level. Relevant information surveyed on the person level refers to socio-economics (age, gender, occupation, education etc.), travel options



entire MOP-Sample. The MOP uses a paper-and-pencil questionnaire and travel diary (Vortisch et al., 2012).

- The **Mobility in Germany (Mobilität in Deutschland, MiD)** is a cross-sectional survey with a large sample size (about 60.000 persons) which is carried out on an irregular basis, depending on funding availability. Surveys with this format were performed in 1976, 1982, 1989, 2002 and 2008. Currently (as of July 2017) a new MiD-Survey is underway. MiD participants fill in a one day travel diary. The reporting days of the respondent are distributed equally over the entire year, i.e. they cover all seasons. There are multiple forms of communicating with the respondents and eliciting travel and other information (telephone interview, online-questionnaire, paper-and-pencil questionnaire) (infas & DLR, 2010b).

Figure 13 shows the annual sample sizes of the MOP and the MiD since 1994. The large MiD sample delivers detailed data, e.g. on the travel behavior by specific subgroups of the population, and input data for many models. The smaller MOP survey helps to monitor the development in between the larger MiD surveys.



**Figure 13: Annual sample sizes of the German National Travel Surveys MiD and MOP since 1994**

#### 4.4.3 Options to Compute Vehicle Mileages from NTS Travel Diaries and Questionnaires in Germany

On the basis of the data surveyed in the German NTS, there are three possibilities to derive vehicle mileages. These use data from the travel diaries as well as data surveyed with additional person, household and vehicle questionnaires.

##### Option 1 - Deriving average VKT from car driver trips in the travel diary

In the travel diary car driver trips are recorded including the km of each trip. By definition these reports also include driver trips in vehicles that don't belong to the household, e.g. when driving a rented car, an ambulance or police car on the job etc. These car driver trip distances can be summed up for the entire person day. Thereafter, these daily total Km on the person level can be extrapolated to annual car km for the entire population. Dividing this total mileage by the total number of cars results in the average number of Km per vehicle per year. However, this does not include information about distributions and differentiating by type of vehicle (e.g. by fuel) is also not possible.

Figure 7 shows that the average annual passenger car mileages derived with this method are relatively close to the result of approaches that are dedicated to establishing vehicle mileages. However, the small sample size of the MOP combined with the strong variance in travel diary travel information (caused by substantial intra-personal day-to-day variation) results in a strong year-to-year variability of the MOP results.

#### **Option 2 - Deriving VKT from estimated annual mileages as reported in vehicle questionnaires**

Both German NTS surveys, MiD and MOP, include vehicle questionnaires asking for detailed information about all vehicles in the respondent households (infas & DLR, 2010a). This also includes estimates about the annual mileages of the cars. This variable can be analyzed directly to compute averages as well as other statistical key figures and information about the distribution. Since the mileages are reported for each vehicle, statistical key figures can also be generated for different types of vehicles.

Figure 7 indicates that this relatively simple way of eliciting car mileages produces results that fall well in line with the results of the other approaches. On average, the vehicle owners appear to make relatively accurate estimates about their annual mileages. One reason for this might be that owners need to indicate predictions about their annual mileages to their insurance companies on an annual basis. The reason for this is that insurance premiums depend on annual mileages of the insured vehicle.

#### **(Option 3 - Deriving VKT through linking travel diary information with the vehicle data)**

This option does not work well for the German data sets. Therefore, we discuss it here as a possibility that exists in theory but is not recommended.

In the MiD travel diary there is not only information on the travel mode that has been used for each trip. In addition, if it was a trip by car, respondents were asked if they used a car that belongs to the household and if so which. With this information, trips can be linked to individual cars of the household. Based on this information, the km per day for each vehicle in the vehicle data set can be computed. Eventually, this can be extrapolated to average vehicle km per year.

This option allows to differentiate vehicle mileage by vehicle characteristics, e.g. by type of fuel. However, for annual vehicle km no other measure than averages can be generated. Distributions for annual mileages and other statistical key figures (mode, median etc.) cannot be derived from the daily figures.

For Germany, this option of deriving mileages generates results that are about a third too low. The reason for this is that many reporting errors on the trip level make it impossible to link the trip to a specific vehicle in the household. As a consequence, vehicle level mileages are too low.

### 4.5 NTS Survey on Fuel Consumption

In addition to the travel diary in fall, MOP participant households with cars take part in a survey on mileage and fuel consumption (in short: Survey on Fuel Consumption). This MOP component takes place between April and June every year. Hence, the survey on fuel consumption is a vehicle based survey that samples the vehicles through sampling households. The Survey on Fuel Consumption covers annually about 1.500 cars.

The questionnaire of the Survey on Fuel Consumption includes questions about vehicle characteristics (make, model, year of construction, type of fuel, engine power, displacement, type of registration etc.) and vehicle use (estimated annual km, use for private or business purposes, type of roads mainly driven on etc.) (Figure 14).

The figure shows two pages of a questionnaire. The left page (back) contains questions about annual mileage, ownership, usage, and household size. The right page (front) contains questions about vehicle characteristics like make, model, year, engine power, fuel type, and tank capacity, along with a fuel gauge visualization.

**Left Page (Back):**

- Wie viele Kilometer wurde dieser Pkw (egal ob von Ihnen oder anderen Personen) im Verlauf des letzten Jahres gefahren? Bitte vergessen Sie eventuelle Urlaubsfahrten nicht. Ca.  km pro Jahr
- Wer ist als Eigentümer dieses Pkw in Ihrem Haushalt im Kfz-Schein eingetragen bzw. wer hat den Pkw geleast?
  - Ich / wir selbst, es ist ein Privatwagen
  - Ich / wir selbst als Inhaber einer Firma
  - Mein Arbeitgeber, es ist ein Dienstwagen
  - Sonstiges, und zwar:
- Wie nutzen Sie diesen Pkw?
  - Fast nur privat
  - Sowohl privat als auch dienstlich / geschäftlich
  - Fast nur dienstlich / geschäftlich
- Wie viele Personen (insgesamt) im Haushalt nutzen diesen Pkw als Fahrer?  Personen
- Gibt es einen überwiegenden Hauptnutzer?
  - Ja
  - Nein
- Gab es im Berichtszeitraum irgendwelche Besonderheiten wie zum Beispiel Autoschaden, Urlaubsfahrten und ähnliches?
  - Nein
  - Ja, und zwar:

**Right Page (Front):**

- TNS logo and household number field:
- Deutsches Mobilitätspanel (MOP) - Studie im Auftrag des Bundesministeriums für Verkehr und digitale Infrastruktur
- Tankbuch - Berichtszeitraum: 24.04. bis 24.06.2017
- Angaben zu diesem Fahrzeug:
  - Erstwagen (meistbenutzter Pkw)  Zweitwagen  Drittwagen
  - Sie finden folgende Angaben zu Ihrem Fahrzeug entweder im Fahrzeugschein bzw. der Zulassungsbescheinigung oder aber in der Betriebsanleitung.
  - Marke / Hersteller:  Typ / Modell:
  - Baujahr / Jahr der Erstzulassung:  Hubraum (in cm³ oder Litern):
  - Leistung (in PS oder KW):  Tankgröße (in Litern):
  - Antriebsart:
    - Diesel  Gas  Elektroantrieb
    - Benzin  Hybrid  Andere Antriebsart:
  - Seit wann (Jahr) ist dieses Fahrzeug in Ihrem Haushalt?
  - Bitte zu Beginn des Berichtszeitraums ausfüllen:
    - Datum:  Kilometerstand des Fahrzeugs:  km
    - Bitte Stand der Tankanzeige kennzeichnen:

**Contact Information (bottom of both pages):**

Ihr Kontakt zu TNS - Landsberger Str. 284 - 80687 München  
 Telefon 089/5600-2157 - verkehrsforschung@tns-infratest.com

Figure 14: Survey on Fuel Consumption questionnaire front (right) and back (left) page, questions about vehicle characteristics and general vehicle use (TNS, 2016)

Bitte tragen Sie alle Tankvorgänge im Berichtszeitraum mit Datum, Kilometerstand, Menge und Kosten in nachstehende Tabelle ein. Bitte kennzeichnen Sie jeweils auch, ob Sie vollgetankt haben.

	Datum	Kilometerstand	Getankter Kraftstoff		vollgetankt?
			Liter	€	
1					<input type="checkbox"/> ja <input type="checkbox"/> nein
2					<input type="checkbox"/> ja <input type="checkbox"/> nein
3					<input type="checkbox"/> ja <input type="checkbox"/> nein
4					<input type="checkbox"/> ja <input type="checkbox"/> nein
5					<input type="checkbox"/> ja <input type="checkbox"/> nein
6					<input type="checkbox"/> ja <input type="checkbox"/> nein
7					<input type="checkbox"/> ja <input type="checkbox"/> nein
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14					<input type="checkbox"/> ja <input type="checkbox"/> nein
15					<input type="checkbox"/> ja <input type="checkbox"/> nein

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20					<input type="checkbox"/> ja <input type="checkbox"/> nein
21					<input type="checkbox"/> ja <input type="checkbox"/> nein
22					<input type="checkbox"/> ja <input type="checkbox"/> nein
23					<input type="checkbox"/> ja <input type="checkbox"/> nein
24					<input type="checkbox"/> ja <input type="checkbox"/> nein
25					<input type="checkbox"/> ja <input type="checkbox"/> nein

Bitte am Ende des Berichtszeitraums ausfüllen:  
Datum:  Kilometerstand des Fahrzeugs:  km  
Bitte Stand der Tankanzeige kennzeichnen:  
    voll

Bitte umblättern ➔

Ihr Kontakt zu TNS - Landsberger Str. 284 - 80687 München  
Telefon 089/5600-2157 - verkehrsforschung@tns-infratest.com

Ihr Kontakt zu TNS - Landsberger Str. 284 - 80687 München  
Telefon 089/5600-2157 - verkehrsforschung@tns-infratest.com

**Figure 15: Survey on Fuel Consumption questionnaire inside pages, refueling log book (TNS, 2016)**

The core element of the survey on fuel consumption is a refueling log book (Figure 15) that survey participants are asked to keep in their car. In this log book, participants enter each refueling event during the two months reporting period including:

- The date of the refueling event
- Km on the vehicle odometer
- Liters of fuel purchased
- Cost of the fuel purchased
- Indication if tank was full after refueling event

Additionally, respondents are asked to indicate the fill level of the tank at the beginning and the end of the two months reporting period.

Based on this information, various data on vehicle use and fuel consumption can be computed:

- **Total amount of fuel consumed** = sum of the fuel purchased at refueling events *plus* fuel in the tank at beginning of reporting period *minus* fuel in the tank at end of reporting period;
- **Total km travelled** = odometer km at end of reporting period *minus* odometer km at begin of reporting period;
- **Average fuel consumption** = total amount of fuel consumed divided by total km travelled:

- **Annual km per car** = Total km travelled *divided by* days of reporting period *multiplied by* 365

Figure 7 shows that the average annual mileages per vehicle as measured by the Survey on Fuel Consumption conform well to the other results. They are somewhat lower than some other results. However, this survey only captures vehicles in private households and excludes other commercial vehicles which on average have higher mileages than private vehicles. Hence, the lower mileages as measured by the survey on fuel consumption are plausible. Despite the relatively small sample size the year-on-year variance of the results of this survey is much smaller than that of the MOP travel diary because of the long reporting period which eliminates some of the variance.

The Survey on Fuel Consumption captures individual vehicle characteristics along with the two month mileage of the vehicles. As a consequence, the results can be differentiated by vehicle characteristics. In addition, the Survey on Fuel Consumption generates information on the distribution of mileages across vehicles and other statistical key figures than just averages can be computed with the resulting data.

## 4.6 Vehicle Use Survey (KiD)

The vehicle use survey (KiD) combines elements of a travel diary survey (as in a National Travel Survey) and a vehicle based survey. In essence, the KiD is a travel diary survey for vehicles. KiD has been conducted in 2002 and 2010 (Wermuth et al., 2012).

The KiD sample is drawn from the federal vehicle register. As in the FLE vehicle owners are requested to participate in the survey. The focus of the KiD-survey is on the use of commercial vehicles. For this reason, more than 80% of KiD participant vehicles are commercial vehicles (Table 3).

Number of vehicles [%]	private	commercial
Motorcycle	650 [1%]	594 [1%]
Passenger car	4482 [6%]	23737 [34%]
Trucks <= 3.5 tons	6781 [10%]	25573 [36%]
Trucks > 3.5 tons	[0%]	4891 [7%]
Tractor units	[0%]	2025 [3%]
Busses	[0%]	384 [1%]
Others		1132 [2%]
Total		70249 [100%]

**Table 3: KiD (2010) sample size and distribution of sample across vehicle categories and types of registration**

The core element of the KiD is a vehicle travel diary in which vehicle owners (or users of the vehicle on the respective day) record every trip of the vehicle on the pre-assigned reporting day. Trip details to be reported include: number of persons in the vehicle, purpose

of trip, type of destination, goods transported, weight of transported goods, address of destination, distance of trip, type of parking at destination. Figure 16 shows the set-up of the KiD vehicle trip diary.

**ANGABEN FÜR**  
Bitte alle Fahrten angeben, die mit diesem Fahrzeug an diesem Tag durchgeführt werden (auch kurze Fahrten, Rückfahrten und private Fahrten).

Ist dieses Fahrzeug am Stichtag VORÜBERGEHEND STILLGELEGT?  
ja 1 / nein 2  
bitte weiter auf Seite 10

Werdn mit diesem Fahrzeug am Stichtag Fahrten durchgeführt?  
ja 1 / nein 2  
bitte weiter auf Seite 10

**PERSONENMERKMALE des ersten Fahrers**  
GESCHLECHT männlich 1 / weiblich 2  
ALTER bis 29 Jahre 1 / 30 bis 44 Jahre 2 / 45 bis 59 Jahre 3 / 60 Jahre und älter 4

**AUSGANGSPUNKT der ersten Fahrt**  
Staat \_\_\_\_\_ Postleitzahl \_\_\_\_\_  
Ort \_\_\_\_\_  
Straße/Hausnummer \_\_\_\_\_

**ART des Ausgangspunktes**  
Wohnung des ersten Fahrers 1  
Sonst. privater Ausgangspunkt 2  
Umschlagpunkt (Bahnhof, Hafen, Spedition etc.) 3  
Baustelle 4  
Land- oder forstwirtschaftliche Fläche 5  
Eigener Betrieb 6  
Fremder Betrieb Industrie/Bau 7  
Fremder Betrieb Handelsdienstleistung 8  
Fremder Betrieb Sonstiges 9  
Kundenhaushalt 10  
Sonstiger dienstl. Geschäft. Ausgangspunkt, und zwar 11

**TACHOSTAND des Fahrzeuges vor Antritt der ersten Fahrt**  
(Tachostand) \_\_\_\_\_ km

Bitte die ersten 10 Fahrten detailliert angeben! Bei Touren ist jeder Fahrabschnitt mit einem bestimmten Ziel (Stopp) einzeln anzugeben.

Um wie viel UHR beginnen Sie diese Fahrt?  
ERSTE FAHRT BEGINN (Uhrzeit) \_\_\_\_\_ : \_\_\_\_\_

Wie viele PERSONEN befinden sich bei dieser Fahrt im Fahrzeug einschl. Fahrer?  
ANZAHL DER PERSONEN IM FAHRZEUG (einschließlich Fahrer) \_\_\_\_\_

Wird bei dieser Fahrt ein ANHÄNGER / AUFLIEGER mitgeführt?  
ANHÄNGER/ AUFLIEGER ja 1 / nein 2

Zu welchem ZWECK unternehmen Sie diese Fahrt?  
FAHRTZWECK Dienstl. Geschäft, Erledigung, und zwar: Holen, Bringen, Transportieren von Gütern, Waren, Material, Maschinen, Geräten etc. 1; Fahrt zur Erbringung beruflicher Leistungen (Mahlzeit, Reparatur, Beratung, Besuch, Betreuung etc.) 2; Holen, Bringen, Befördern von Personen (dienstl. Geschäft.) 3; Sonst. dienstl. Geschäft, Erledigung 4; Rückfahrt zum Betrieb/Stellplatz 5  
Private Erledigung, und zwar: Fahrt zum Arbeitsplatz 6; zur Ausbildung 7; privater Einkauf 8; Freizeit, Erholung 9; Holen, Bringen, Befördern von Personen sonst. privater Erledigung 10; nach Hause 11

Um was für ein ZIEL handelt es sich?  
ART DES ZIELES Umschlagpunkt (Bahnhof, Hafen, Spedition etc.) 1; Baustelle 2; Land- oder forstwirtschaftliche Fläche 3; Eigener Betrieb 4; Sonstiges dienstl. Geschäft. Ziel, und zwar 5; Fremder Betrieb Industrie/Bau 6; Fremder Betrieb Handel/Dienstleistung 7; Fremder Betrieb Sonstiges 8; Kundenhaushalt 9

Welche FORM(EN) hat die Ladung bei dieser Fahrt?  
FORM DER LADUNG (Mehrfachnennungen möglich) Keine Güter 1; Massengüter (Unverpackt) 2; Behälter / Wechselbehälter 3; Fahrzeuge 4; Paketiertes Gut 5; Gebundene Güter 6; Stückgut 7; Andere Ladungsformen 8

Welches BRUTTOGEWICHT hat die gesamte Ladung bei dieser Fahrt?  
GEWICHT DER LADUNG (einschl. Anhänger) Bis 50 kg 1; Mehr als 50 kg, und zwar \_\_\_\_\_ kg 2

Welche GÜTERART hat bei dieser Fahrt den höchsten Gewichtsanteil?  
GÜTERART Bei mehreren Güterarten das Gut mit dem höchsten Gewichtsanteil (bitte keine Markennamen) Pakete / Päckchen 1; Briefe / Dokumente 2; Sonstiges (z. B. Zement), und zwar 3

Wo liegt das ZIEL?  
ZIELADRESSE Staat \_\_\_\_\_ Postleitzahl \_\_\_\_\_ Ort \_\_\_\_\_  
Straße/Hausnummer \_\_\_\_\_

Um wie viel UHR sind Sie dort angekommen?  
ANKUNFT (Uhrzeit) \_\_\_\_\_ : \_\_\_\_\_

Welche ENTFERNUNG haben Sie bei dieser Fahrt zurückgelegt?  
FAHRTWEITE (Tachostand) \_\_\_\_\_ oder \_\_\_\_\_ km (gefahrte Kilometer)

Wo wird das Fahrzeug am Ziel abgestellt?  
ART DES STELLPLATZES AM ZIEL Parken, Halten im öffentlichen Straßensaum 1; Parken, Halten auf Privatgrundstück 2; Parken, Halten im Parkhaus, Tiefgarage etc. 3

nächste Fahrt, nächste Spalte  
wenn letzte Fahrt, bitte weiter auf Seite 10

Figure 16: KiD vehicle trip diary (Wermuth et al., 2012)

Average annual VKT can be computed from the KiD trip data set. Therefore, the trip distances per vehicle need to be aggregated over the entire reporting day. This results in km per day which can be extrapolated to average km per year.

However, in the German case KiD average VKT values and even more so the strong decline between 2002 and 2010 are questionable (Figure 7). The relatively small private passenger car sample size in combination with the short reporting period of just one day (given strong day-to-day variation of vehicle use) are likely to explain these problems.

## 4.7 VKT Calculations for National Transport Statistics

Detailed vehicle specific VKT and total VKT have to be established as source data at one point in time as presented in the above chapters. However, these approaches are either costly and therefore infrequent (at best), or they use samples which are too small to give detailed and representative results. Additionally, all methods have particular errors. So it will be difficult if not impossible to establish a closed and consistent time series on this basis alone.

For the German national transportation statistics (ViZ), national VKT is computed annually based on information which is readily available each year (Kuhfeld, Kunert, Link, & Radke, 2014): total fuel consumption for road transport, statistics on the vehicle stock composition and statistics on average fuel consumption per vehicle-km. The basic idea of the model is the identity of the total annual fuel consumption with the product of the average fuel consumption and average VKT summed over all vehicle classes. We postulate this identity for the VKT travelled by German vehicles in Germany and abroad. This method is outlined in Figure 17.

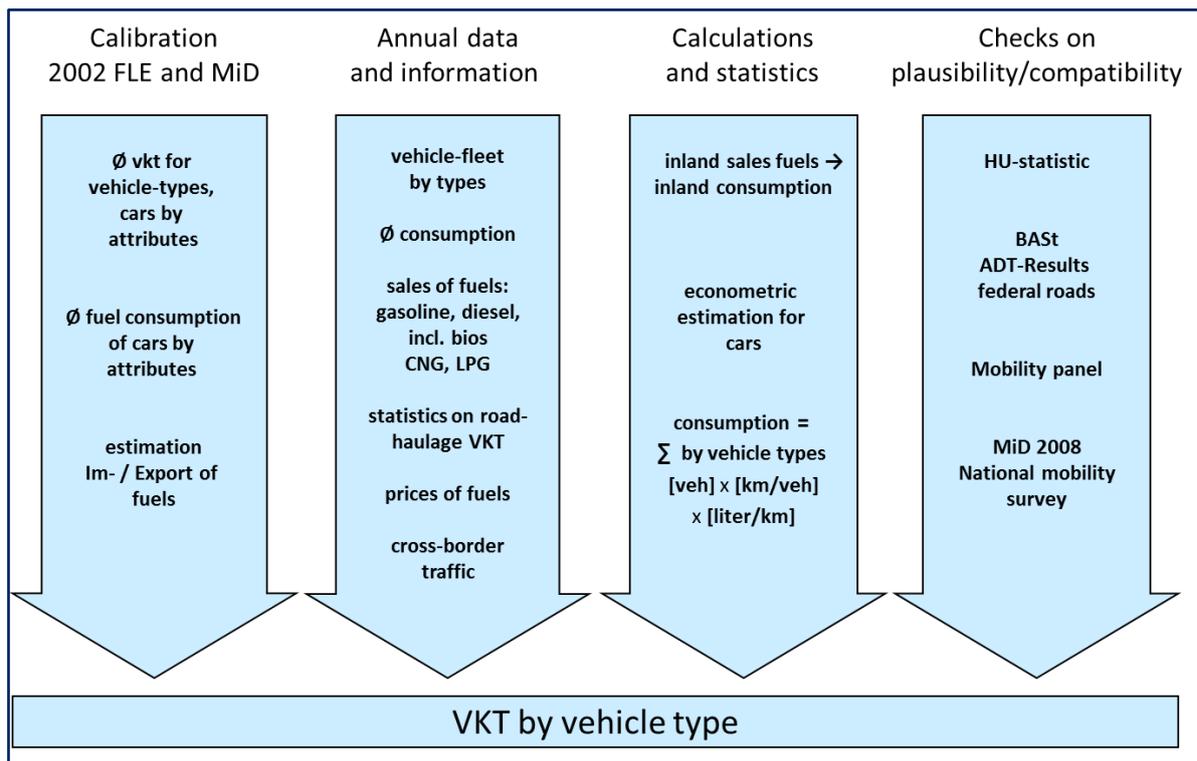


Figure 17: Outline of the method of VKT calculation for the National Transport Statistics

### 4.7.1 Calibration 2002

The current ViZ-method was launched with the data of the 2002 mileage survey FLE and the national travel survey MiD. The 70 000 data records (vehicles) of the FLE-survey were used to calculate average annual VKT for vehicle types. For connecting the survey results with the annual vehicle stock statistics, the vehicle types had to be defined accordingly.

Information on average fuel consumption was taken from diverse records, especially from the publicly available motor press. This data also comes with some degree of uncertainty, yet the real life values (test results by various sources) for cars are higher than the ones recorded in the official test procedure for the type approval of new cars.

Total sales of different fuels are reported by official statistics and the shares used by different sectors of the economy have to be calculated based on auxiliary data.

Additionally, the issue of imports and exports of fuels by German or foreign vehicle drivers became important. Germany has nine neighboring countries and since 1998 fuel prices in Germany tended to be higher than in most of these countries. Thus, German vehicles increasingly tended to refuel abroad while foreign vehicles tended less to refuel in Germany. This development was intensified with the inclusion of additional countries into the EU.

To estimate the quantity of fuels im- and exported based on some regularly available data, information on the cross-border traffic (by light and heavy duty vehicles) and on the price differentials of fuels (Gasoline and diesel) along these borders were used.

Given the high response rates and good quality of the 2002 surveys and the good confidence strengthened by the continuity of estimates that can be computed by both surveys (e.g. average annual VKT by diesel driven cars) the interdependencies of specific fuel consumption, annual VKT, vehicle stock size and total fuel consumption (sales) was balanced for the year 2002.

Since 85 % of VKT of national vehicles is produced by cars, it is advisable to analyze the car segment in detail. Therefore the 1993 and 2002 sample surveys of motor vehicle mileage with vehicle (including test fuel consumption data) and holder's attributes were used for a statistical analysis of the factors that determine VKT. The comparable data records for two years made it possible to determine changes as to the influence of these structural effects over time and to establish parameters to estimate annual mileage and specific fuel consumption. The results indicate year to year changes in VKT and fuel use as driven by the structure of the car stock.

### 4.7.2 Annual Data and Information for Updating

For the annual updating of the ViZ time series several data inputs are necessary, most importantly a data base of the current vehicle stock. This data is provided by the Federal Motor Transport Authority (KBA) giving detailed attributes and numbers of individual vehicles for the end of year date. We use this stock to estimate the VKT for the preceding year.

---

The vehicle data is matched with the information on specific fuel consumption for this year. Like most of the information and data used in this ViZ context, the values can only change little from year to year.

Information on total sales of fuels by fuel category, on cross border traffic and on fuel prices in neighboring countries are collected by midyear. Additionally a German/EU statistic on road haulage VKT is used for the respective classes of goods vehicles (Bundesamt für Güterverkehr, 2017).

### 4.7.3 Annual Calculations

Two approaches are followed for the annual calculations: a very detailed econometric analysis for the car segment and a balancing model for all vehicles in an excel-spreadsheet. For the statistical analysis the car attributes (e.g. holder private/commercial, fuel type diesel/gasoline, engine power, vehicle age, etc.) of the current stock are used to estimate the year on year difference in VKT and fuel consumption. The information on cross border traffic and on fuel prices in neighboring countries allows correcting the domestic fuel sales to the fuel supply for domestic vehicles.

The results of the statistical analysis for cars are used in the spreadsheet with further vehicle classes to balance fuel demand and fuel supply over some 20 vehicle categories.

### 4.7.4 Results and Checks on Compatibility

In the resulting tables total fuel consumption is the outcome of a detailed breakdown of vehicle stock, average VKT and average fuel economy. The total VKT for vehicle classes can be compared to some other statistics to check for compatibility: the HU-statistics, the MOP values and the average daily traffic on federal roads.

### 4.7.5 Pros and Cons of the Approach

The ViZ-method yields a detailed, regular, timely (mid-year) and cost efficient estimate of VKT and fuel demand. Inputs and results are consistent with other national statistics.

Some of the information/data needed are not well measurable or not well documented so that a high degree of expertise has to be applied.

## 4.8 Federal Road Traffic Counts

Under the supervision of the Federal Highway Research Institute (BASt) there is a system in place which monitors the volume of traffic on federal highways including “Autobahn” (Interstate Freeways) and “Bundesstraßen” (Federal Trunk Roads). This system comprises of two elements (Fitschen & Nordmann, 2014, 2016; Lensing, 2013):

**Automated continuous traffic counts:**

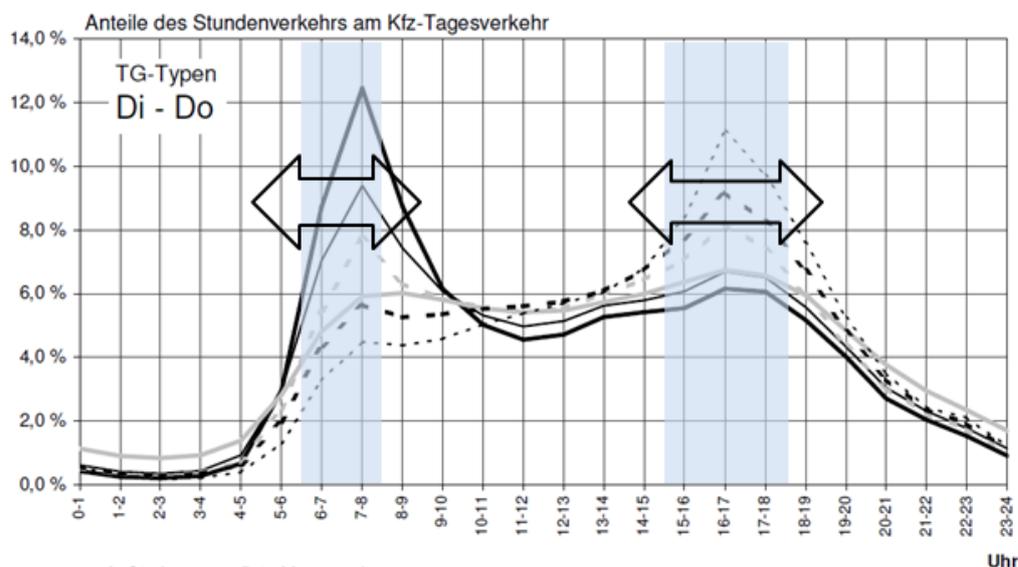
- About 1.800 automated counting facilities monitor traffic on the Germany federal highway system. This translates to one counting facility for each 30 km of highway.
- These automated continuous traffic counts monitor traffic during 24 hours on 365 days of the year. This means they generate demand profiles for the hours of the day, the days of the week and the seasons of the year.
- Over 90% of the automated counting facilities are able to differentiate vehicles by 9 vehicle types (two-wheelers, cars w/o trailers, cars with trailers, light trucks, trucks, trucks with trailers, tractor units, busses, and vehicles that can't be identified).

**Manual traffic counts:**

- Manual traffic counts of the entire federal highway system are conducted every five years. These traffic counts are performed by the federal states according to regulations issues by the Federal Highway Research Institute (BAST) (BMVI Referat StB 11, 2015).
- There are about 13.000 counting locations. This translates to one counting facility for each 4 km of highway which ensures complete coverage of the network.
- The manual traffic counts are performed only on selected days (considered “average days”) during specific hours of the day (e.g. 7-9 am and 15-18 pm).
- Like the automated traffic counts, the manual traffic counts distinguish 9 types of vehicles.

Hence, while the automated traffic counts deliver complete temporal coverage of the traffic on the federal highway system, the manual traffic counts deliver a complete spatial coverage of the network. By integrating the insights from both counting systems, the complete annual VKT on the German federal highway system can be extrapolated. We are not going into the details here, but Figure 18 illustrates the principles of extrapolating from hourly counts to the entire day: the 24h demand profiles are provided by the automated traffic counts; the manual traffic counts on the respective days take place from 7-9 am and from 15-18 pm. Combining the information allows for extrapolating from the hourly counts to the entire day, from specific types of days to entire weeks, and from weeks to the entire year.

In a similar manner the data from the automated and the manual counts are combined to achieve a complete spatial coverage of the network.



**Figure 18: Hourly demand profiles on a typical weekday (Tuesday to Thursday) for different types of roads**

## 4.9 Discussion of the Approaches

Table 4 summarizes the various approaches to establish vehicles mileages presented in this background paper. The upper part of the table shows the methodological key points of the different approaches. The row “Expense/effort” shows a qualitative assessment of the effort involved to implement the respective approach. Basically, surveys involve a much larger effort and higher costs than modelling approaches. A large part of the cost that comes with conducting surveys is manpower, e.g. for counting or conducting interviews. As the cost for this varies strongly across locales, cost structures cannot be transferred from Germany to other locales. Therefore, we only show a qualitative assessment of the respective effort. A more detailed analysis is required to generate cost estimates for application of the approaches outside Germany.

The lower part of Table 4 shows the type of result that can be generated based on the respective approach. Not all approaches allow for the same break down of the results by dimension, e.g. vehicle class or type of road. Only a combination of approaches provides for complete coverage of VKT by various dimensions.

#### 4 Approaches for Establishing Vehicle Mileages

	Vehicle Use survey (KID)	FLE Vehicle owner survey	NTS travel diary & questionnaire		Survey on fuel consumption	FLE Traffic Counts	Federal road traffic counts	VKT from inspection data	VKT for National Transport Statistics
			NTS travel diary	NTS questionnaire					
<b>Methodology overview</b>									
Type of approach/data	Survey	Survey	Survey	Survey	Survey	Traffic count	Traffic count	Model	Model
Sample origin	Vehicle register	Vehicle register	Population register, random dialing	Population register, random dialing	Random dialing	Random road network links	Selected road network link	n.a.	n.a.
Observed unit	Vehicle	Vehicle	Person	Vehicle	Vehicle	Road link	Road link	n.a.	n.a.
Reporting period	1 day	10 weeks	1 day / 7 days	n.a.	8 weeks	1 day	continuous	n.a.	n.a.
Reported events/units	Vehicle trips	Odometer km	Person trips	Mileage estimates	Fueling events	Passing vehicles	Passing vehicles	n.a.	n.a.
Frequency	Irregular	Irregular (10-12 years)	Irregular/annual	Irregular/annual	Annual	so far once	Annual / every 5 years	Annual	Annual
Expense/Effort	+++	+++	+++		++	+++	+++	+	+
<b>Result overview</b>									
Average mileage per vehicle	Yes	Yes	Yes	Yes	Yes	(Yes, excl. Mileage abroad)	No	Yes	Yes
Distribution of annual mileage across vehicles	No	Yes	No	Yes	Yes	No	No	(Yes)	No
Average mileage by type of vehicle	Yes	Yes	No	Yes	Yes	Limited (vehicle shape)	No	Yes	Limited
Vehicles covered	Domestic vehicles	Domestic vehicles	Domestic vehicles	Domestic vehicles	Domestic vehicles	Vehicles on domestic roads	Vehicles on domestic roads	Domestic vehicles	Domestic vehicles
Mileage covered	All Km	All Km	All Km	All Km	All Km	Domestic Km	Federal trunk roads	All Km	All Km
Mileage by type of road	No	No	No	No	No	Yes	Yes (trunk roads)	No	No
Variability across days/months	Yes	(Yes)	Yes	No	No	Yes	Yes	No	No

**Table 4: Methodology and result overview over presented approaches**

## 4.10 Applications of VKT data

VKT is a metric used extensively in transportation planning and research for a variety of purposes. Transportation agencies, environmental agencies and consultants use this data to perform various functions over and above computing energy consumption and estimating vehicle emissions, which is the focus of this project.

Other applications of VKT data include:

- In road safety analysis (which is the motive and financing source for the FLE in Germany) VKT is the measure of exposure of vehicles or travelers to accident risks. VKT by vehicle or driver characteristics in relation to occurred accidents indicates how prone to accidents certain segments are.
- The information on the traffic volume on road segments allows assessing other traffic impacts. E.g. road and traffic engineering has to identify pavement maintenance needs using VKT by weight classes of vehicles.
- In regulatory impact analysis or in general behavioral analysis VKT (by vehicle and driver characteristics) often serves as the indicator for travel demand and behavior. For example, when evaluating the impacts of tightening fuel economy standards, a research question is to what extent travel demand increases and whether performance of the vehicles (kW) changes. Likewise, the response of travelers to fuel price changes is measured by VKT to estimate elasticities.

## 5 Options for Establishing Vehicle Stock and Vehicle Mileage Statistics in Vietnam

This section presents a summary of the expert conclusions from the workshop taking place in Serena Resort on July 12 and 13 2017. During the workshop, the approaches applied in Germany and selected other countries were presented. Based on this presentation, the workshop group consisting of Vietnamese experts and stakeholders, German experts, Worldbank representatives, and GIZ-representatives discussed possible approaches applicable in Vietnam.

The generation of a bottom-up emission inventory is the motivation for collecting data on transport for Vietnam beyond data that is currently available, asking for data on vehicle stock, vkt and fuel consumption. Due to an ongoing revision of the circular on transport statistics, there is a chance that the collection of these will be formalized in the upcoming year. Therefore suitable data collection methods have to be identified.

This section summarizes conclusions after the discussion during the workshop concerning the collection of data on vehicle stock and VKT in the road sector. An important outcome of the workshop is that there are several feasible options to close existing data gaps. This section presents various options and it points to important questions that need to be answered in order to select the best approaches for Vietnam. As the workshop discussion focused on vehicles for ground transportation (two-wheelers, cars, trucks), vessels for inland waterway navigation for which data gaps are also relevant were not the focus of the discussion and will not be covered here. This summary concentrates on cars and two-wheelers.

## 5.1 Vehicle Register Data and Data on the Stock of In-Use Vehicles

For the emissions inventory data on the stock of vehicles that are actually in use is required. A natural starting point to establish figures on the in-use vehicle stock are vehicle registers. The workshop discussion was very useful in clarifying which vehicles are contained in the vehicle register of Vietnam Register. However, it also pointed to additional questions which need to be clarified in order to establish the in-use vehicle stock. The status (to our understanding) and remaining questions are presented in the following, separating cars and two-wheelers.

### 5.1.1 Passenger Cars

In Vietnam, new car and truck registrations take place at local registration offices which are operated by Vietnam Register.. The local registers are combined into a central / federal register. As a result, there is a central vehicle register containing an accumulated number of vehicles. This central register is a data base containing individual vehicles.

In principle, the Vietnam Register vehicle data base is a cumulative register, i.e. it accumulates new vehicle registrations. However, there are also vehicles which are eliminated from the register. This applies to trucks which have an expiry age, i.e. an age beyond which they must not be operated anymore and are eliminated from the register (25 years). However, passenger cars do not have an expiry date. Nevertheless, there are some passenger cars which are eliminated from the register, e.g. if there was an accident with total loss, after which the car was deregistered.

Data from vehicle tax payments or vehicle insurances is not linked to the vehicle register. This means that vehicles can remain in the register, even if vehicle tax has not been paid or if the vehicle is not insured.

As a result, the passenger car register contains vehicles which are still in use as well as vehicles that are not in use anymore (e.g. because they are broken down or have been sold abroad) but have never been de-registered.

Against this background, there are two options to establish figures on in-use passenger cars:

- **In-use car stock based on vehicle inspection data:** passenger cars have to undergo regular vehicle inspection. Those cars that do not show up for inspection can be identified in the register as vehicles that are not in use. This approach requires linking information from the vehicle inspections with the vehicle register (see below) and the introduction of a new variable/indicator for each individual entry in the vehicle data base indicating if the car is in use or not. This appears to be the most precise method of establishing a data base of in-use-passenger cars that can be applied in Vietnam.
- **In-use car stock based on secondary data sources:** Secondary data sources such as household surveys (e.g. new household travel surveys or existing living standard surveys) or insurance data or tax data (number of passenger cars that tax is paid for) can be used to establish the total number of cars in use. However, not only the total number of cars is required but also a break down by characteristics (e.g. type of fuel). To obtain this information, a virtual data base of in-use vehicles could be generated from combining the vehicle register with the information on in-use vehicles. One way of doing this would be to copy the passenger car register data base and keep only the correct number of in-use vehicles by eliminating an appropriate number of old vehicles. This methods should only be considered as an alternative if option 1 does not work as it delivers less precise information on the in-use vehicle stock

### 5.1.2 Two-Wheelers

For two-wheelers there is no central register at Vietnam Register as two-wheeler registrations are administered by the Road Traffic Police. Hence, only the police keeps a register of two-wheelers which does not appear to be accessible. As a consequence, information on the stock of two-wheelers in use can only be obtained from surveys, with household surveys being the most likely option (see below).

### 5.1.3 Additional comments on establishing vehicle stock based on household surveys

As mentioned above household surveys can be utilized to establish in-use vehicle stock for both cars and two-wheelers. Scaling up figures for a total (e.g. national) fleet from a survey sample is possible. However, methods to do this require reliable statistics on either the total number of households in the country or the total population in the country which represent the expansion frame.

In principle, the following computation procedures can be applied to obtain the total national vehicle fleet:

- A. If the expansion frame is the total number of households (i.e. the total number of households is known for the country of interest):
  1. compute the number of vehicles per household based on the household survey sample
  2. multiply the number of vehicles per household by the total number of households in the country
- B. If the expansion frame is the total number of persons (i.e. the total population for the country of interest):
  1. compute the number of vehicles per person based on the household survey sample
  2. multiply the number of vehicles per person by the total number of persons in the country

Among these, method A. is the more common procedure.

However, while A. and B. are the underlying theoretical principles of computing the total vehicle fleet from a survey sample, the computation procedure in practice is often different: In order to counter survey selectivity, surveys are usually weighted, i.e. household data sets contain expansion factors that are combined with weights. Applying these weights/expansion factors when running analyses makes sure, survey results are unbiased (or less biased) than the actual survey. Hence, in practice one would simply run the required analysis applying the respective household or person weight.

As such, computing the total national vehicle fleet based on a weighted national household survey in practice works with the following formula:

$$\text{total national vehicle fleet} = \sum_i NV_i \times W_i$$

where  $NV_i$  is the number of vehicles of household  $i$  in the survey and  $W_i$  is the expansion factor of household  $i$ .

It is important to assess household vehicle ownership or vehicle availability such that double counting of vehicles is avoided. For example, there might be vehicles in use by several households, e.g. across members of the same family who do not live together. If survey questions are stated such that respondents in both households are inclined to report the respective vehicle, this is likely to result in double counting of vehicles. A question leading to double counting could be for example: "How many vehicles do you use?". A more precise question would be "How many vehicles are registered on individuals living in your household?". The latter question avoids double counting.

## 5.2 Vehicle mileage data

In addition to vehicle stock data, the emission inventory requires data on average vehicle mileages (e.g. average annual vehicle mileage). Again different approaches appear suitable to establish mileages for passenger cars and two-wheelers.

### 5.2.1 Passenger cars

The regular vehicle inspections which passenger cars have to undergo are the most reliable source for deriving vehicle mileages. Deriving vehicle mileages from regular vehicle inspections requires obtaining necessary data items from the vehicles as they come to the inspection. First and foremost that is the mileage on the odometer. In addition, technical characteristics of the vehicle and the date when the vehicle was first registered should be established. This data, however, could also be drawn from the vehicle register which requires a linkage between the data drawn at inspections and the vehicle register. Against this background, three options for establishing mileage for passenger cars in Vietnam appear feasible:

- 1. Longitudinal vehicle inspection data:** When odometer mileages are drawn from individual cars at vehicle inspections and this information is linked (or added) to the entry of the respective vehicle in the vehicle register, mileages from different consecutive vehicle inspections can be used to monitor the mileage trend for individual vehicles over time. This requires linking the information from inspections to the vehicle in the register, e.g. through a unique vehicle identification number. Based on this total mileages or average mileages per passenger car group (e.g. by age or type of powertrain) can be extrapolated using an appropriate extrapolation method.  
This is the most precise and reliable option for establishing mileages for passenger cars.
- 2. Cross-sectional vehicle inspection data:** If direct linkage of vehicle inspection data to vehicle data in the register is not possible, vehicle inspections data can be used nevertheless. In this case, all required technical information, the age of the vehicle (or the date when the vehicle was first registered) must be elicited at the inspection. From this data, overall average annual mileages can be extrapolated based on the approach applied in Germany and described in section 4.3 of this background paper.  
This is a possible alternative to option 1 if establishing a longitudinal data set with data from vehicle inspections is not possible.
- 3. Vehicle mileages from household surveys:** If drawing mileages for passenger cars from inspections is not possible, mileages can also be established in a household survey. Such a household survey will be described for two-wheelers in the following section. This approach can also be combined with approach 2

(above) as it can deliver useful additional information to calibrate the extrapolation method for option number 2.

This option as a stand-alone approach (i.e. without combining it with option number 2) should only be considered if deriving car mileages from inspections is not possible (surveys come with high costs, usually do not deliver annual up-to-date data and go along with substantial uncertainties).

## 5.2.2 Two-Wheelers

For two-wheelers there is no requirement to undergo regular vehicle inspections in Vietnam. As a consequence, household or on-street / intercept surveys appear to be the most feasible possibilities to establish mileages for two-wheelers. As there is no accessible two-wheeler register either, no two-wheeler sample can be drawn. Hence, a household survey focusing on vehicles would have to be based on a random sample of households. The different survey options to establish two-wheeler mileages are presented below. At this point, there is no clear indication which of these approaches (or which combination of approaches) can be recommended. Thorough studies to answer open questions and to test applicability of the methods are indispensable. Only on the basis of such studies a decision can be made which of the options delivers quality information and is cost efficient.

In following we present three survey options for establishing two-wheeler mileages and point to open questions which need to be answered in order to make a decision as to which approach is the most suitable option for Vietnam.

1. **Household mileage survey with repeated odometer reading:** A sample of households is drawn, e.g. by random-route-walking. Households are interviewed (ideally face-to-face) about their socio-economic characteristics as well as on the ownership of two-wheelers, cars (see section on car stock and car mileages) and other possible vehicles. Technical details of the two-wheelers (and – if necessary - other vehicles) are asked for. In order to keep the respondent burden low, questions should only cover items that respondents can answer easily. Most importantly, the questionnaire asks for the vehicle mileage. The following items can serve to elicit mileage information:
  - self-estimated annual, monthly or weekly vehicle mileage
  - a cross-sectional odometer reading (km on odometer) on a given date
  - repeated odometer readings, e.g. if the household is revisited after an adequate period of time (e.g. two months, 10 weeks).

A prerequisite for this survey format is that odometers by and large deliver reliable information. This should be tested with a suitable sample size of two-wheelers beforehand.

2. **Household travel survey:** Again a household sample is interviewed about socio-economic characteristics and vehicle ownership. As opposed to option 1, the focus of the survey here is on eliciting multimodal travel information through a travel diary. When asking for travel mode information on the trip level, it is important to differentiate the driver and passenger mode for cars and for two-wheelers. Only with this information it will be possible to compute average vehicle mileages (see 4.4.3 of this background paper). When making sure that respondent burden is not too high, a household travel survey could also be combined with option 1.
3. **On-street or intercept survey:** As an alternative (or supplement) to a household survey, mileage information could also be surveyed through an on-street or intercept survey. In such a survey, two-wheeler drivers could be stopped on street or approached at suitable locations (e.g. gas stations) and interviewed on site. Questionnaires should cover basic technical information about the vehicle. Mileage could be elicited through self-estimated annual/monthly/weekly mileages and odometer readings. The odometer readings can be extrapolated through a suitable modelling approach to total average annual mileages (see 4.3 of this background paper). When extrapolating to the total vehicle population is must also be considered that high mileage vehicles have a higher likelihood of being covered by the survey due to the sampling procedure. This must be corrected by suitable design weights.

This survey format is likely to be the one that can be implemented the quickest and deliver data the fastest; however, it delivers the least reliable data among the approaches. However, also this survey format requires reliable odometers. In addition, the suitability of the testing sites (e.g. gas stations) must be analyzed first.

### 5.3 Usage of other data sources

In addition to new data sources which can be initiated to establish mileages as described above, it is also important to explore existing data sources which contain information on vehicle stock or vehicle use. Examples for such data sources are

- Living Standard / Income and expenditure surveys as they might contain information on the ownership of durable goods, among them cars and two-wheelers as well as expenditure for fuel;
- Insurance information on the question for how many vehicles (cars) are insured (see section 3.5.1);
- Tax information on the question how many vehicles (cars) tax is being paid for (see section 3.5.2).

## 5.4 Concluding remarks

The summary of our conclusions about suitable methods for vehicle stock and vehicle mileage establishment in Vietnam clarifies that at this point there appear to be several options. The selection of the most suitable approach requires further analysis and information. Most critical issues from our viewpoint are:

- Possibilities of linking vehicle inspection data to vehicle register data
- Reliability of odometer measurements
- Available methods of drawing samples
- Knowledge of vehicle users/survey respondents about the characteristics of the vehicle

Only after clarifying these issues, suitable methods that fulfil the needs of the Vietnamese transport statistics can be selected and specified in detail (e.g. questionnaire design).

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