EVOLUTION OF THE FIGURES OF CASUALTIES FOR BUS/COACH OCCUPANTS WITH CORRESPONDING RISK INDICATORS COMPARED TO THOSE FOR OCCUPANTS OF CARS AND GOODS VEHICLES

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Abstract -The paper gives an overview of the recent (mostly 2012) figures of killed bus/coach occupants (drivers and passengers) in 27 Member States of the European Union as reported by CARE. The Evolution of the figures of bus/coach occupants killed in road accidents urban, rural without motorway and on motorways from 1991 to 2010 in 15 Member States of the EU supplements this information.

More detailed are the figures reported for Germany by the Federal Statistics. The paper displays long-term evaluations (1957 to 2012) for killed, seriously and slightly injured occupants in all kinds of buses/coaches. Mid-term evaluations (1995 to 2012) of the figures of fatalities and casualties are displayed for different busses according to their identification of road using as coaches, urban buses, school buses, trolley buses and "other buses".

To be able to compare the evolutions of the safety of vehicle occupants it is customary to use different risk indicators. Calculations and illustrations for three often used indicators with their development over time are given: fatalities, seriously injured and slightly injured per 100,000 vehicles registered, per 1 billion (10^9) vehicle-kilometres travelled and per 1 billion (10^9) person-kilometres. These indicators are shown for occupants of cars, goods vehicles and buses/coaches.

For the period from 1957 until 2012 it is obvious, that for all three vehicle categories analysed there was a clear long-term trend towards more occupant safety in terms of casualties per vehicles registered and per vehicle mileage. This was most significant for car occupants but it can be seen for bus/coach occupants and goods-vehicle occupants as well.

Figures of killed occupants and of casualties related to person-kilometres are calculated and displayed for the shorter period 1995 to 2012. Here it becomes obvious that the bus/coach is still the safest mode of transport for the occupants of road vehicles. Graphs for the casualty risk indices still show significantly higher risks for car occupants despite the corresponding curve moved sustainable downwards. It is remarkable, that the risks of being killed or injured for the occupants of urban buses is growing whereas the corresponding risk for the occupants of coaches in line traffic tends downwards.

The article ends with a short comparison and discussion of the risk indicators which are actually published for the occupants (driver and passengers) of cars and the passengers of buses/coaches, railroads, trams and airplanes. The interpretation of such information depends on the perception and it seems that for a complete view not only one indicator should be used and the evolutions of the indicator values during longer periods (as displayed with examples in the paper) should also be taken into account.

KEY WORDS

Bus, Coach, Statistics, Accident, Fatalities, Casualties, Risk Indices

INTRODUCTION

Since decades to travel in buses and coaches is one of the safest modes of passenger traffic. Furthermore bus travels are most friendly to the environment. For urban and short-trip transport as well, the bus is an important alternative to travel by car. For long-distance-line travelling (remote-bus traffic) new possibilities are licensed by law in Germany since January 1st, 2013 and opened new possibilities for the customers. This gives good reason for updated overviews on the accident figures and risk indicators for occupants of buses/coaches (vehicle categories M_2, M_3) and compare them for example to those for occupants of cars (M_1 vehicles as an alternative to travel on roads) and of goods vehicles (categories N_1, N_2, N_3) which are in general more heavier road vehicles than cars.

BUS/COACH OCCUPANT FATALITIES IN THE EUROPEAN UNION

The European database CARE (Community database on road Accidents Resulting in death or injury) reports the current total number of traffic fatalities for the year 2012 with last refresh date on March 17, 2014 as 28,459 (all road users) [1].

The data come from 27 member states of the EU (EU 28 without Lietuva which is not reporting to CARE) and they are continuously maintained and updated by the latest available national statistics. On the stated day there was a total of 92 killed occupants of buses/coaches of which 20 were drivers (22%) and 72 passengers (78%), **Table 1**.

In CARE, road fatalities are defined as road users who die due to the consequences of an accident immediately or within 30 days. Buses/coaches (buses, minibuses, coaches and trolleys) are defined as passenger-carrying vehicles, having more than 16 seats for passengers. Buses are most commonly used for urban public transport, coaches for interurban movements and touristic trips. To differentiate from other bus types, a coach has a luggage hold separate from the passenger cabin. Relative to the total of 28,459 fatalities (all road users) in the 27 member states, 92 killed bus/coach passengers represent a proportion of only 0.3%.

Table 1: Current figures of bus/coach drives and passengers killed per year in road accidents in 27 member states of the EU (Source: CARE [1] last refresh date: March 17, 2014)

State	Belgique	Bulgaria	Ceská Republica	Danmark	Deutschland	Eesti
Year	2011	2009	2012	2012	2012	2009
Driver	2	0	1	1	0	0
Passengers	0	0	1	0	3	2
State	Éire	Elláda	Españia	France	Hrvatska	Italia
Year	2010	2011	2012	2012	2012	2012
Driver	1	1	0	2	1	1
Passengers	0	3	3	5	7	6
State	Kýpros	Latvija	Luxembourg	Magyarország	Malta	Nederland
Year	2012	2012	2012	2012	2010	2012
Driver	0	0	0	1	0	0
Passengers	0	3	0	2	0	1
State	Österreich	Polska	Portugal	România	Slovenijya	Slovensko
Year	2011	2012	2012	2012	2011	2010
Driver	0	7	0	1	0	0
Passengers	2	11	2	9	0	0
State	Suomi	Sverige	Great Britain	EU-27 = EU-28 without Lietuva*		
Year	2012	2010	2012	-		
Driver	0	1	0	20		
Passengers	1	1	10	72		

* Lietuva is not reporting to CARE

For Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxemburg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom (EU-15) it was possible to identify in CARE the number of bus/coach occupants killed annually from 1991 to 2010 for each year broken down to the location (urban, rural without motorway, motorway) of the accidents, **Figure 1**. The maximum was recorded in 1992 with a total number of 266 killed bus/coach occupants. In 2010, the reported number was 72. Most of these bus/coach occupants died in accidents outside urban areas. The proportions in 2010 are: 15 fatalities urban (21%), 22 fatalities rural without motorway (31%) and 35 fatalities on motorways (49%).

The 3rd European Road Safety Action Programme set the objective of cutting in halve the number of killed road traffic participants for the whole of the European Union (EU-27) over the period 2001 to 2010 [2]. This objective was almost attained by a reduction of 44% from 54,000 to 39,500 (all road

users). In the member states considered here (EU-15) the number of bus/coach occupants killed fell from 196 in 2001 to 72 in 2010, i.e. by 63%. This means that bus/coach occupants participated well in the general development towards steadily improved safety levels on the roads of the EU.

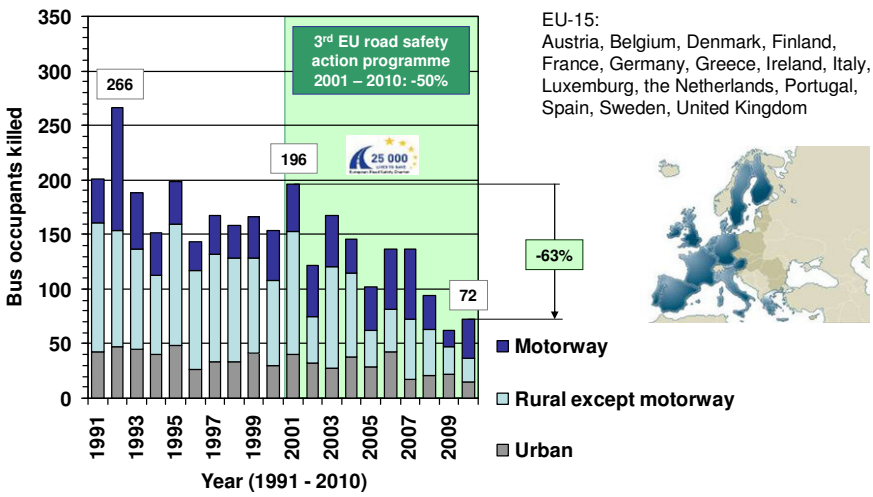


Figure 1: Bus/coach occupants killed per year in road accidents in 15 member states of the European Union (EU-15) from 1991 to 2010 (data source: CARE [1] with last refresh date on March 17, 2014)

CASUALTIES IN BUSES/COACHES ON GERMAN ROADS

In 2012 a total of 3,600 road users died in Germany, 66,279 were seriously and 318,099 slightly injured. Bus/coach occupants formed a very low proportion of these casualties with 3 fatalities, 394 seriously and 5,274 slightly injured. Only 0.08% of the fatalities, 0.6% of the seriously injured and 1.7% of the slightly injured road users are bus/coach occupants. In the German accident statistics fatalities are persons who died within 30 days as a result of the accident. Seriously injured are persons who were immediately taken to hospital for inpatient treatment of at least 24 hours. Slightly injured are all other injured persons. Occupants of buses/coaches are defined as those travelling in a motor coach or bus (tourist bus, bus of the line, school bus) or a trolleybus.

When interpreting the numbers it needs to be noted that only those killed or injured in road accidents are included in the statistics. For example, near Hanover 20 people died in a bus disaster on the A2 Autobahn in 2008. This was not the result of a road accident because the bus caught fire as a consequence of an “internal operation” [3].

The number of bus/coach occupants killed or injured in road accidents annually since 1957 can be extracted from the publications of the Federal Statistical Office [4, 5, 6]. **Figure 2** shows the long-term evolution of the numbers of killed bus/coach occupants up to 2012. The numbers given for 1992 and afterwards apply to the Republic of Germany after the re-unification in 1990 – i.e. both “old and new Laender”. The graph displays that the numbers of killed bus/coach occupants certainly remains at a very low level with sinking long-term trend. But the individual annual figures vary considerably.

The maximum number of fatalities during the stated period was 74 recorded in 1959. In that year the most serious bus accident in Germany since the 2nd World War occurred. In the city of Lauffen at the river Neckar (Baden-Württemberg) a bus travelling over a level crossing was struck by the locomotive of an express train, **Figure 3**. 45 bus occupants were killed [6, 7].

The previous minimum was 2 bus/coach occupants killed in 1998. 3 killed bus/coach occupants were registered in 2012. The substantial variation over time of the annual numbers of fatalities is significantly influenced by individual serious accidents in which a relatively large number of occupants were killed. **Table 2** contains four examples for 1959, 1992, 2007 and 2010.

Figure 2:
Bus/coach occupants killed in accidents on roads in the Federal Republic of Germany per year from 1957 to 2012
(data source: Federal Statistical Office [4, 5, 6])

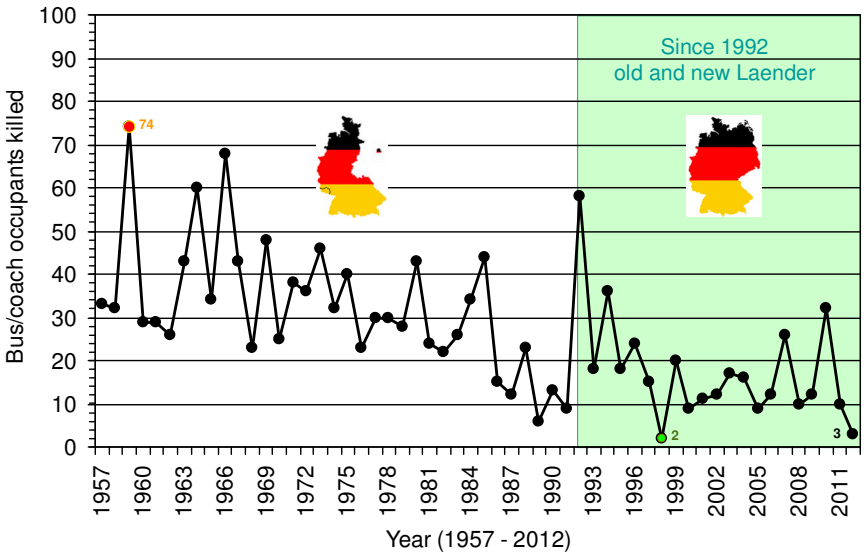


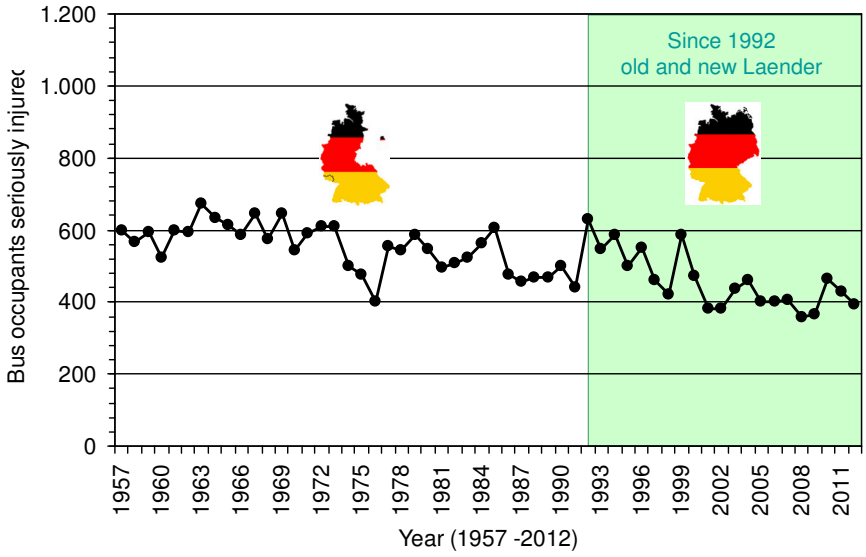
Figure 3: The most serious bus accident in Germany since the 2nd World War occurred on June 20, 1959, in the city of Lauffen at the river Neckar (Baden-Württemberg)

Table 2: Examples of single catastrophic bus/coach accidents which significantly influenced the figure of killed bus/coach occupants in the corresponding year

Accident Date	Accident description	Bus/coach occupants killed in the described accident	Bus/coach occupants killed during the entire year	Share in bus/coach occupants killed during the year
June 1959	Bus struck on a railway level crossing by the locomotive of an express train	45	74	61%
Sept. 1992	Coach tilts after forcing a car and crashes into a guardrail	20	58	34%
June 2007	Truck crashes into the rear end of a coach	13	26	50%
Sept. 2010	Coach crashes into a car and a bridge post after evasion manoeuvre	13	32	41%

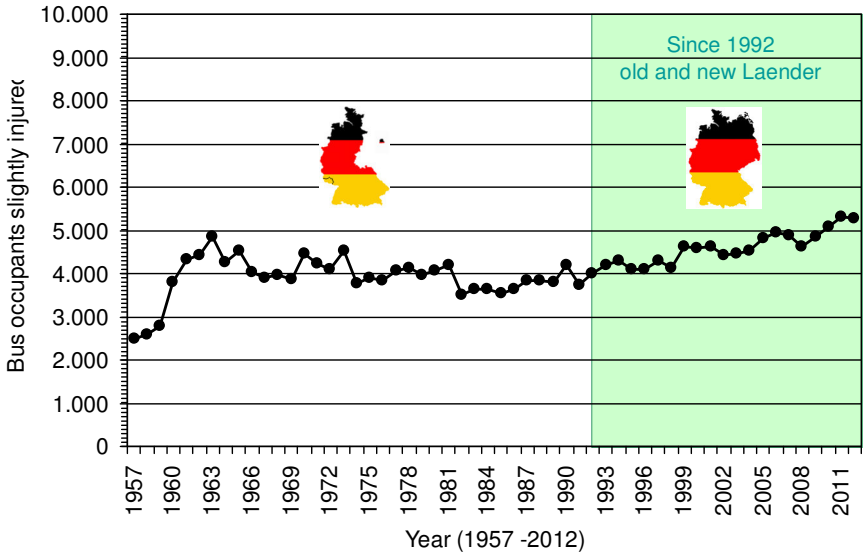
The long-term evolution of the figures of severely injured bus/coach occupants (see **Figure 4**) is less influenced by annual variations than the number of occupants killed. In the 'old Laender' of the Federal Republic of Germany (1957 -1991) brief periods of falling numbers were followed by some clear increases. In the period following the reunification (figures since 1992), a sustained falling trend in the numbers of severely injured occupants could be observed up to now over the long term. This means that bus/coach occupants had their share as well in the general trend offering greater vehicle and traffic safety on German roads. 394 severely bus/coach occupants have been registered for 2012.

Figure 4:
Bus/coach occupants severely injured in accidents on roads in the Federal Republic of Germany per year from 1957 to 2012 (data source: Federal Statistical Office [4, 5, 6])



To complete the picture, the long term evolution of the figures of slightly injured occupants of buses/coaches is displayed in **Figure 5**. Here the figures did grow in the late 1950s and early 1960s to a maximum of 4,846 in 1963. Afterwards this figure more or less trends marginally downwards until the reunification and then it grows again. 5.274 slightly injured bus/coach occupants were registered for 2012.

Figure 5:
Bus/coach occupants slightly injured in accidents on roads in the Federal Republic of Germany per year from 1957 to 2012 (data source: Federal Statistical Office [4, 5, 6])



For more detailed interpretations the figures of casualties for buses/coach occupants can be separated in terms of the particular vehicle function (described in the Federal statistics with "category of road user"). The official statistics differentiate between coaches (tourist bus), urban buses (bus of the line), school buses and trolleybuses (bus electrically propelled trough a trolley line). There is also a category for "other buses" that covers buses/coaches which the police who is on spot responsible for the accident data collection were unable to assign to one of the above-mentioned categories.

According to the statistics available, the low numbers of fatalities and their sub portions alter in wide ranges, **Figure 6**. For the individual years 1998, 2001 and 2006 no killed coach occupants were registered in the official statistics. In other years, such as 2002, 2003, 2007 and 2010 the number of coach occupants killed are dominant compared with the total number of all bus/coach occupants killed. From 1996 to 1998, 2000 to 2006, in 2008, 2010 and 2012 no occupants of school busses lost their life in a road accident. For trolley buses, no killed occupants were registered in all years displayed here. The larger numbers of casualties (i.e. injured and killed) are always dominated by the occupants of urban buses, **Figure 7**.

Figure 6:
Fatalities in buses/coaches in Germany per year from 1995 to 2012 broken down into sub-groups corresponding to the function ("category of road user") of the vehicles (data source: Federal Statistical Office [5])

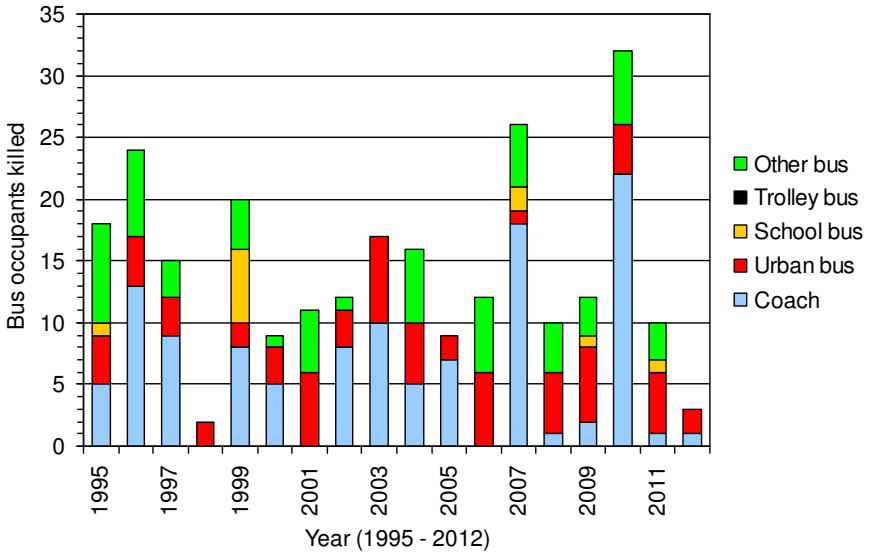
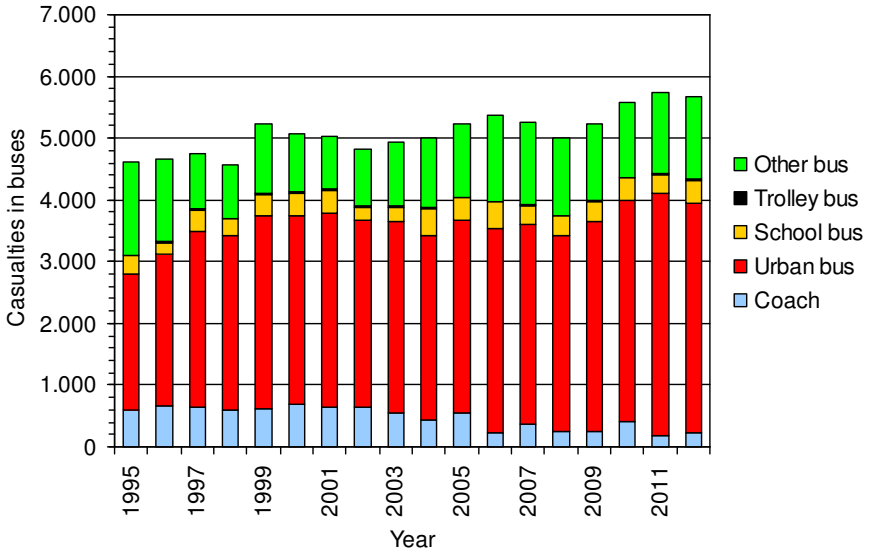


Figure 7:
Casualties in buses/coaches in Germany per year from 1995 to 2012 broken down into sub-groups corresponding to the function (category of road user) of the vehicles (data source: Federal Statistical Office [5])



In individual years the number of fatalities or casualties associated with "other buses" is still relatively high. For example, 6 fatalities in 2010 representing 19% of the total of 32 killed bus/coach occupants were registered as occupants of "other buses". It can, therefore, be assumed that the real numbers of casualties in urban buses, coaches and, where appropriate, school buses could be as well greater than shown by the statistics.

The over-riding objective is to steadily reduce the absolute number of persons killed in traffic accidents. This is reflected by Vision Zero, a worldwide strategy initiated in Sweden and promoted in Germany by the German Road Safety Council (DVR) [9]. The Accident Statistics show that Vision Zero had already become a “temporary reality”, not only for the occupants of trolley buses and school buses, but also for coach occupants on German roads during individual years.

Furthermore, accident records especially for coaches demonstrate the importance of the constantly expressed statement that “every traffic death is one death too many”. The public memory retains severe individual coach accidents for a long time but takes no account of the individual years in which no coach occupants die. Severe coach accidents always provide occasion to refer to the fact that “according to the statistics, the long-distance coach is the safest mode of passenger transport on roads”. However, in a current view to dramatic real consequences of an accident, the abstract statistics fade into insignificance. So there is only a limited opportunity to persuade the public to accept on a sustained basis the desired image that coach travel is "the safest way to make a land journey". With this background it can be seen that there needs to be an over-riding strategic aim for all those involved, to take appropriate measures to ensure that the number of bus/coach accidents remains as low as possible, but also that the consequences of a serious accident, which can never be entirely eliminated, are kept to an absolute minimum.

RISK INDICATORS

To be able to compare the safety of vehicle occupants (drivers and passengers) it is customary to use several risk indicators. Illustrations of how the values of three often used indicators have developed over time are given below.

Casualties per 100,000 vehicles registered

Indicator values calculated as killed occupants per 100,000 vehicles registered are published annually with the official German statistics [4]. Figures for 2012 are shown in **Table 3**. This kind of indicator is easy to calculate using official figures of casualties (killed or injured occupants) which are published from official sources [4, 5, 6]. Here, figures of registered buses/coaches are reported as well.

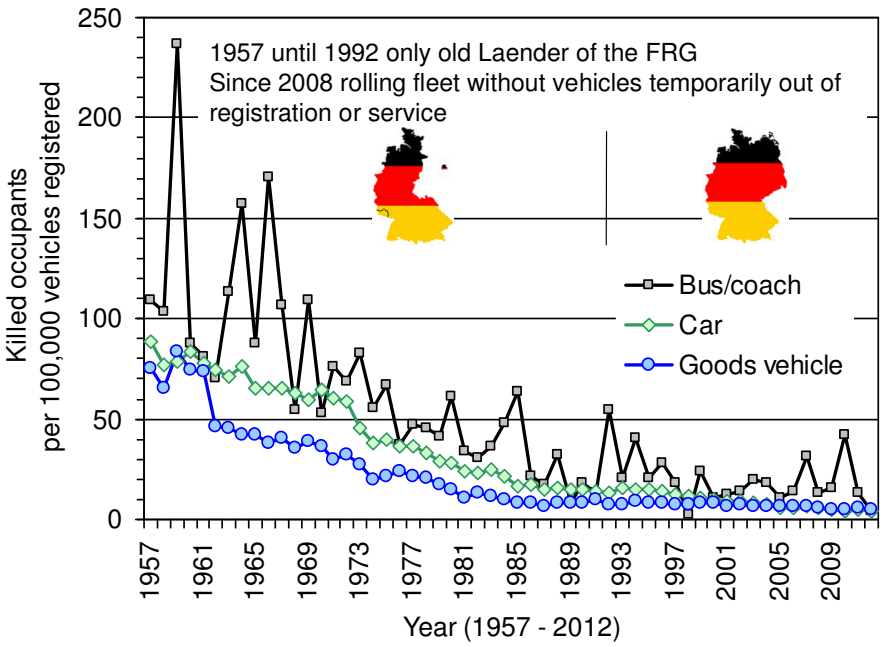
The figures for casualties relate to the numbers of fatally, seriously or slightly injured occupants of German (and foreign!) vehicles which are involved in accidents on German roads. Used as scale bases are the corresponding figures of vehicles registered (in Germany only!). It should be noted, that from 2008 onwards vehicles which are temporarily out of registration or service are excluded from the official figures of vehicles registered. This means that since 2008 the calculated indicator values are really based on the figures of vehicles in the rolling stock.

Table 3: Killed occupants per 100,000 vehicles registered in Germany as published for the year 2012 with the annual official statistics [4]

Vehicle category	Motor vehicles	Cars	Motorcycles	Mofa/Mopeds	Goods vehicles
Killed occupants per 100.000 vehicles registered	4,9	4,2	15,0	4,5	4,7

Figure 8 compares the evolution of the indicator values related to buses/coaches, cars and goods vehicles from 1957 to 2012. Since the data only applies to re-unified Germany from 1993 onwards, for the time up to and including 1992 only figures recorded in the statistics of the 'old Laender' of the Federal Republic of Germany (FRG) have been taken into account.

Figure 8:
Risk indicator values for occupants of buses/coaches, cars and goods vehicles calculated as killed per 100,000 vehicles registered in the Federal Republic of Germany from 1957 to 2012 (Data source: Federal Statistical Office, [4, 5, 6])



Here too, the influence of single severe bus/coach accidents causing a widely varying pattern of bus/coach occupants killed annually can be seen. There was a significant reduction of the indicator values until and including the 1980s for all three vehicle categories displayed. This confirms the general trend towards a higher level of road traffic safety. For later years the curves flattens out.

It is noteworthy that the indicator values for car occupants and for goods vehicle occupants have converged. 4.2 occupants of cars and 4.7 occupants of goods vehicles have been killed per 100,000 vehicles of the corresponding fleets in 2012. In 1998 when only 2 bus/coach occupants were killed and the number of buses/coaches registered was 83,285 the corresponding indicator value was 2.4 occupants killed per 100,000 buses/coaches. Such a favourable result was not achieved in any other year when the indicator value for buses/coaches was usually greater than for cars and goods vehicles. In 2010 with 32 killed bus/coach occupants and 76,433 of such vehicles registered, the indicator value is calculated to 41.9 killed occupants per 100,000 vehicles. As already mentioned before, such effects are due to the significant unfavourable influence exerted by relatively large numbers of occupants of buses/coaches who were killed in individual accidents. For 2012 the indicator value is 3.9 occupants killed per 100,000 buses/coaches and lays in the same region as the values for cars and gods vehicles.

To complete the picture, **Figures 9** and **10** display the indicator values based on the figures of vehicles registered for the seriously and slightly injured occupants of buses/coaches, cars and goods vehicles. In all the years from 1957 to 2012 this indicator shows greater values for bus/coach occupants than for occupants in cars or goods vehicles. This is as well due to the much greater figure of occupants in a bus/coach. If an accident occurs, the potential for a greater figure of occupants being slightly or seriously injured increases correspondingly.

In recent years the indicator values for cars and goods-vehicle occupants have converged with a clear trend. 68 severely injured and 435 slightly injured car occupants respectively 58 severely injured and 249 slightly injured goods-vehicle occupants, each per 100.000 vehicles registered, are the results for

2012. The corresponding values for seriously injured bus/coach occupants remains nearly constant around 500 since the end of the 1990s. In the same period for slightly injured bus/coach occupants the indicator value was growing up to 6.941 in 2012.

Figure 9:
Risk indicator values for occupants of buses/coaches, cars and goods vehicles calculated as seriously injured per 100,000 vehicles registered in the Federal Republic of Germany from 1957 to 2012 (Data source: Federal Statistical Office, [4, 5. 6])

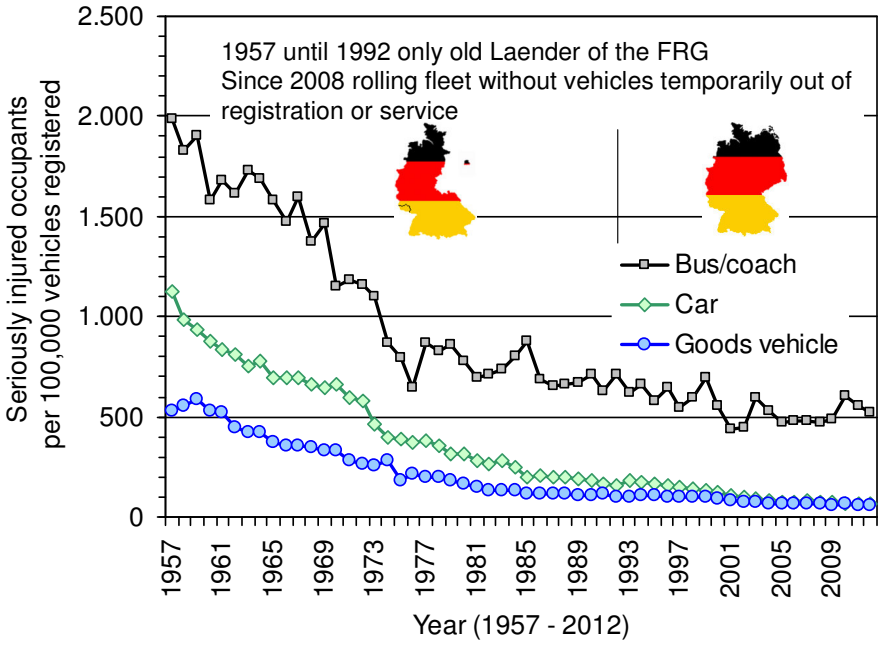
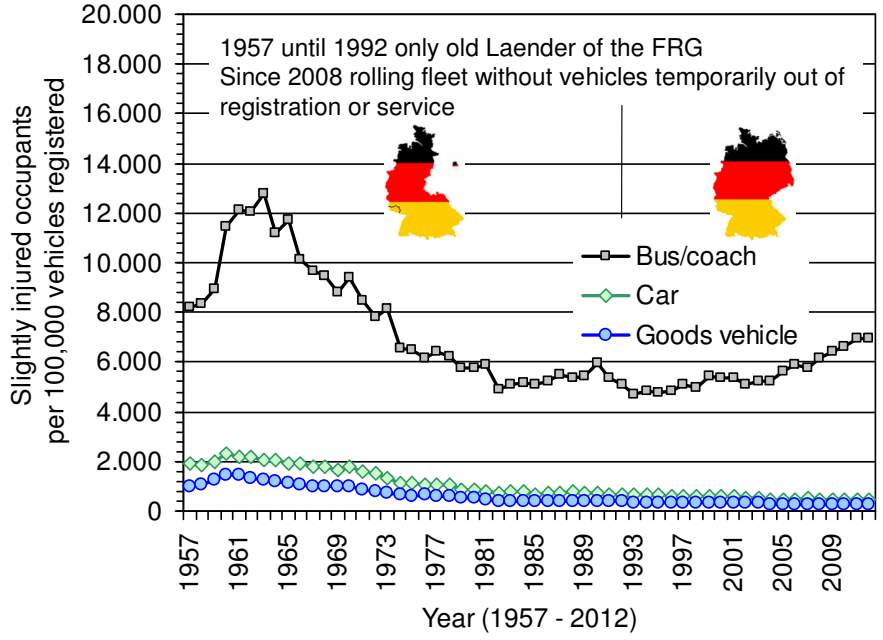


Figure 10:
Risk indicator values for occupants of buses/coaches, cars and goods vehicles calculated as slightly injured per 100,000 vehicles registered in the Federal Republic of Germany from 1957 to 2012 (Data source: Federal Statistical Office, [4, 5, 6])



The indicator related to the total rolling-stock figures of vehicles is quite abstract. It indeed is suitable for recognising and comparing different categories of vehicles. However, it does not permit a real derivation of the level of risk to which individual vehicles and their occupants are exposed because that risk is additionally related to both vehicle mileage travelled and the number of occupants in a vehicle.

Casualties per 1 billion vehicles-kilometres travelled

Indicator values describing casualties and fatalities for all road users (including cyclists and pedestrians) per 1 billion (10^9) vehicle-kilometres travelled are published annually in the official German statistics [4] as well. Here, 547 casualties and 5.1 killed, each per 1 billion vehicle-kilometres are reported for 2012.

Such risk indicators also can be calculated as the relation between the numbers of occupants killed, severely or slightly injured and the total mileage annually travelled per vehicle in the corresponding category. They can be clearly explained: The inverse proportion corresponds to the average risk that an individual occupant of a vehicle will be killed (or severely injured or slightly injured) in a road traffic accident after travelling a specific mileage.

Data necessary for the calculations are published for certain vehicle categories in the Federal statistics [4, 5, 6] and in publications from the Deutsches Institut für Wirtschaftsforschung (DIW) [10]. The mileages result from the use of a calculation model. One of the determining factors is the total annual fuel consumption in Germany. The result is called as "natives mileage". This means the mileage of registered German vehicles including their mileage travelled on foreign roads [11].

Figure 11 displays the evolution of this indicator values for fatally injured occupants in buses/coaches, cars and goods vehicles from 1957 to 2012. Again the period from 1957 to 1990 covers only the "old Laender" of the FRG and from 1991 onwards the "new Laender" are included.

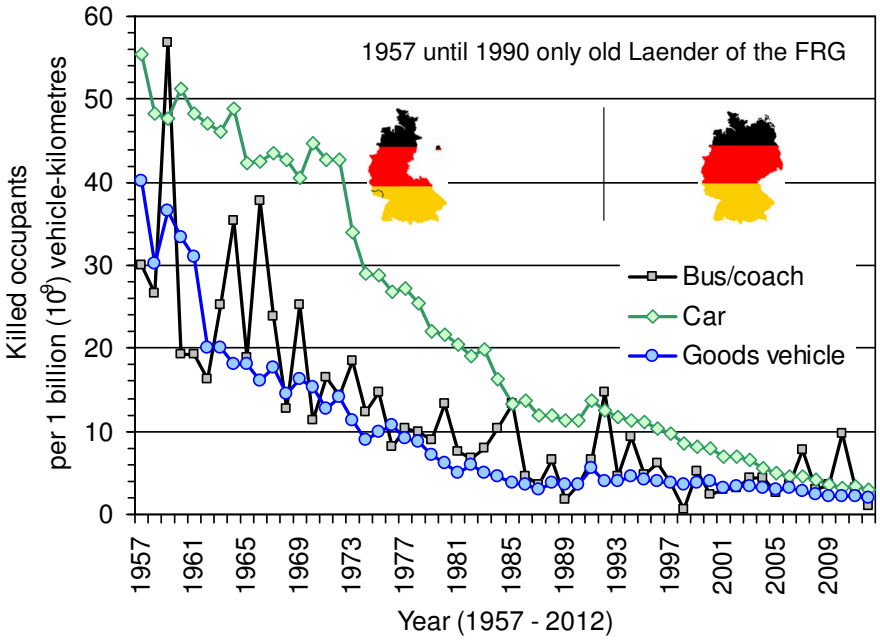


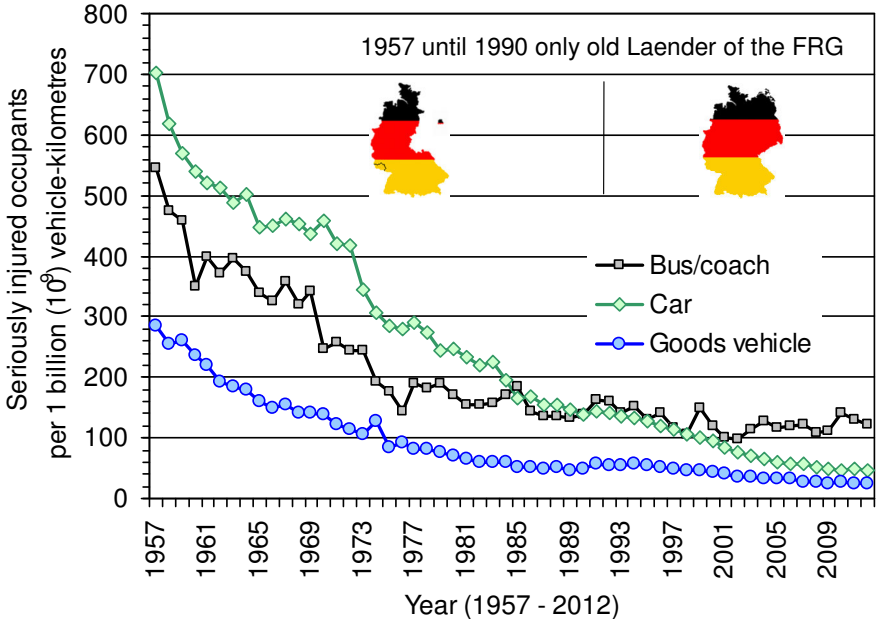
Figure 11: Risk indicator values for occupants of buses/coaches, cars and goods vehicles calculated as killed per 1 billion (10^9) vehicle-kilometres for the Federal Republic of Germany from 1957 to 2011 (Data sources: Federal Statistical Office, [4, 5, 6], Deutsches Institut für Wirtschaftsforschung DIW [10])

Here too, for all three vehicle categories clear trends to smaller indicator values are displayed, which indicate sustainable progress in road traffic safety. This is most significant for cars but can be seen with smaller extent for the occupants of goods vehicles and for buses/coaches as well. As far as buses/coaches are concerned, there is again a considerable influence of severe accidents in individual years which widely vary the annual indicator values. Until 2012 the three lines converged to values of 0,9 killed occupants per 1 billion vehicle-kilometres for bus/coach occupants, respectively 2.9 for car occupants and 1.9 for goods-vehicle occupants.

In **Figure 12** the evolution of the corresponding indicator values for seriously injured occupants is displayed. Over the long term the curve for cars starts at the highest level, crosses the curve for bus/coaches in 1990 and is then with smaller values closer to the curve for goods vehicles. In 2012 the indicator value is 123 seriously injured bus/coach occupants, 47 seriously injured car occupants and

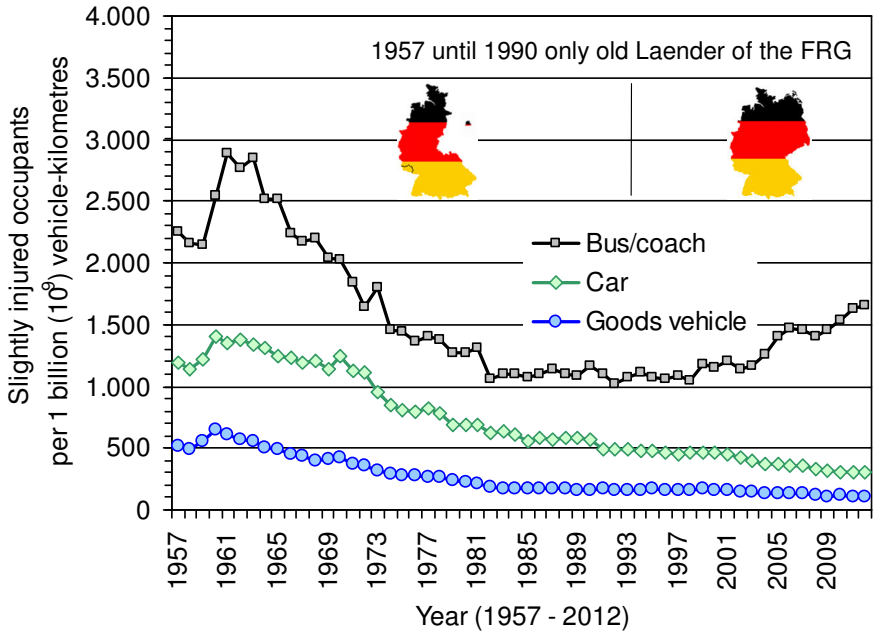
24 seriously injured goods vehicle occupants, each per 1 billion vehicle-kilometres travelled. It is remarkable, that in contrast to the values for cars and goods-vehicles the values for buses/coaches did not further decline since 2001/2002.

Figure 12:
Risk indicator values for occupants of buses/coaches, cars and goods vehicles calculated as seriously injured per 1 billion (10^9) vehicle-kilometres for the Federal Republic of Germany from 1957 to 2011 (Data sources: Federal Statistical Office, [4, 5, 6], Deutsches Institut für Wirtschaftsforschung DIW [10])



To again give the complete picture, **Figure 13** shows the corresponding curves for the slightly injured occupants. Similar to the evolution of slightly injured occupants per 100.000 vehicles registered (see Figure 10) the curve for buses/coaches is on the highest level and shows increasing values since the end of the 1990s. Values for 2012 are 1,653 slightly injured bus/coach occupants, 304 slightly injured car occupants and 102 slightly injured goods vehicle occupants, each per 1 billion vehicle-kilometres.

Figure 13:
Risk indicator values for occupants of buses/coaches, cars and goods vehicles calculated as slightly injured per 1 billion (10^9) vehicle-kilometres for the Federal Republic of Germany from 1957 to 2011 (Data sources: Federal Statistical Office, [4, 5, 6], Deutsches Institut für Wirtschaftsforschung DIW [10])



Casualties per 1 billion person-kilometres

Casualties per billion (10^9) person-kilometres is a further indicator by which the transport performance of vehicles can be considered. Indicator values calculated as fatalities per 1 billion person-kilometres are often used by the federal statistical office to compare the safety of public passenger transport (buses, underground railway and similar modes, passenger trains) to the risk of car occupants. This indicator as well can be clearly explained: Its value corresponds to the average figure of occupants who died (or are injured) as the consequence of a road accident after the vehicle has travelled a mileage of 1 billion kilometres.

For the period 2007 to 2011 some values are published as shown in **Table 4** [12]. For public transport modes the values are calculated using the figures of killed passengers only (without driver and other staff). For cars the value is calculated using the figure of killed occupants (driver and passengers). This means for a car the driver is seen as a "passenger" as well. Taking into account all occupants with the additional consideration of killed bus/coach drivers results in a light shift of the risk value from 0.23 to 0.29 for all bus/coach occupants, **Table 5**.

Table 4: Risk indicator values calculated as killed occupants/passengers per 1 billion person-kilometres (1 billion = 10^9) for different modes of transport in Germany for the period 2007 to 2011 (Source: Federal Statistical Office [12])

Vehicle category	Car	Bus	Underground railways and similar modes	Passenger train
killed occupants /passengers* per 1 billion person-kilometres	2.49	0.23	0.04	0.04

*for cars calculated using the figures of killed occupants (driver and passenger), for other modes calculated using the figures of killed passengers only

Table 5: Risk-Indicator values calculated as killed per 1 billion person-kilometres for bus/coach occupants (driver and passengers) in Germany for the period 2007 to 2011 (Data source: Federal Statistical Office [4, 6])

Year	Killed bus/coach occupants			Bus/coach transport performance [10^9 person-km]	Risk indicator values [killed per 1 billion person-kilometres]		
	drivers	passengers	occupants		drivers	passengers	occupants
2007	7	19	26	65,387	0.11	0.29	0.40
2008	1	9	10	63,592	0.02	0.14	0.16
2009	3	9	12	62,097	0.05	0.14	0.19
2010	5	27	32	61,743	0.08	0.44	0.52
2011	1	9	10	61,367	0.02	0.50	0.16
Mean value	3.4	14.6	18	62,837	0.05	0.23	0.29

Risk indicators related to the transport performance are "classical" measures indicating the bus/coach with its large number of occupants to be the safest means of road travel. Corresponding to figures published in the official statistics the evolution of the values for fatalities and casualties of occupants of cars, goods vehicles, coaches in non-scheduled traffic (long-distance coach) and urban buses (line traffic) from 1995 to 2012 can be calculated with results displayed in **Figure 14** and **Figure 15**.

For cars and goods vehicles the figures of person-kilometres are based on the reported figures of their annual mileage [10] and on calculated figures of occupants per vehicle in accidents with personal

injury which are published in the official statistics as well [4, 5]. As shown in **Table 6** for car occupants the calculated figures of occupants per vehicle range from 1.43 to 1.56 for the period from 1995 to 2012. In the same way (but not shown here with a table) for goods vehicles 1.21 to 1.26 occupants per vehicle can be calculated. For coaches in non-scheduled traffic and buses in line traffic, the figures of their mileage are reported by official statistics directly [6].

Table 6: Calculated figures of occupants per car and of transport performance of cars with the figures for occupants killed per 1 billion person-kilometres as the final result using figures published in official statistics [4, 5, 10]

Year	Car occupants killed published in [4, 5]	Mileage of cars [10^9 km] published in [10]	Cars involved in accidents with personal injury for which the figure of occupants is known published in [4]	Known figures of car occupants published in [4]	Occupants per car calculated	Transport performance of cars [10^9 pers.-km] calculated	Occupants killed per 10^9 pers.-km calculated
1995	5,929	535.1	499,066	779,192	1.56	835.5	7.1
1996	5,622	539.5	482,593	750,045	1.55	838.5	6.7
1997	5,249	542.7	485,462	749,940	1.54	838.4	6.3
1998	4,741	550.8	486,102	744,383	1.53	843.4	5.6
1999	4,640	566.2	502,732	766,102	1.52	862.8	5.4
2000	4,396	559.5	486,158	736,056	1.51	848.0	5.2
2001	4,023	575.5	478,463	721,257	1.51	867.5	4.6
2002	4,005	583.6	459,454	690,916	1.50	877.5	4.6
2003	3,774	577.8	435,565	651,891	1.50	864.8	4.4
2004	3,238	590.4	417,800	621,770	1.49	878.6	3.7
2005	2,833	578.2	405,392	601,042	1.48	857.2	3.3
2006	2,683	583.9	392,131	577,163	1.47	859.4	3.1
2007	2,625	587.5	399,655	585,251	1.46	860.4	3.1
2008	2,368	584.6	374,758	544,662	1.45	849.6	28
2009	2.110	595.0	365,289	528,965	1.45	861.7	2.4
2010	1,840	599.0	343,627	497,737	1.45	867.7	2.1
2011	1,986	608.8	358,358	515,875	1.44	876.4	2.3
2012	1,791	610.1	354,144	506,736	1.43	872.9	2.1

As the graphs display, for killed occupants of urban buses very low risk factors are given, without any exception. In 2012 that risk factor was 0.05 occupants killed per 1 billion person-kilometres.

The risk for occupants of long-distance coaches generally is very low, too. In this instance, however, because of the relatively high number of persons killed in individual years (2007: 18 fatalities, 2010: 22 fatalities), the risk attached to these vehicles is in some years significantly greater than for urban buses. For 2010 there is a value of 1.0 occupants in long-distance coaches killed per 1 billion person-kilometres. For 2011 this value was dropped down to 0.1 and for 2012 it remained with a value of 0.05 on a very low level.

Figure 14:
Risk indicator values for occupants of urban buses, coaches, cars and goods vehicles calculated as killed occupants per 1 billion person-kilometres for Germany from 1995 to 2012, Data sources: Federal Statistical Office, [3,5], Deutsches Institut für Wirtschaftsforschung DIW [10])

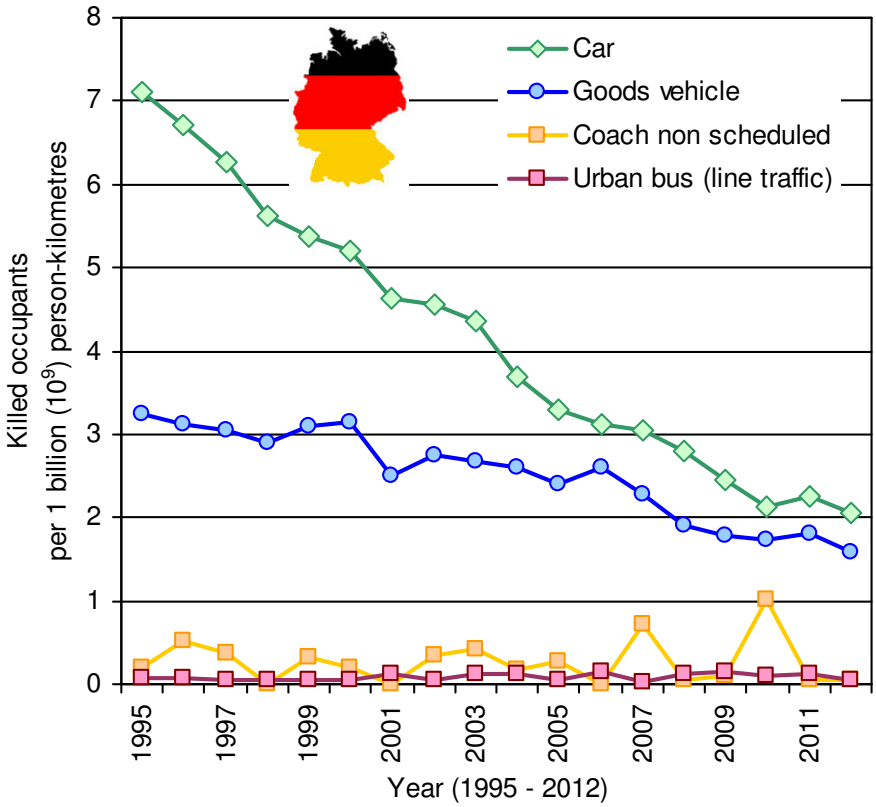
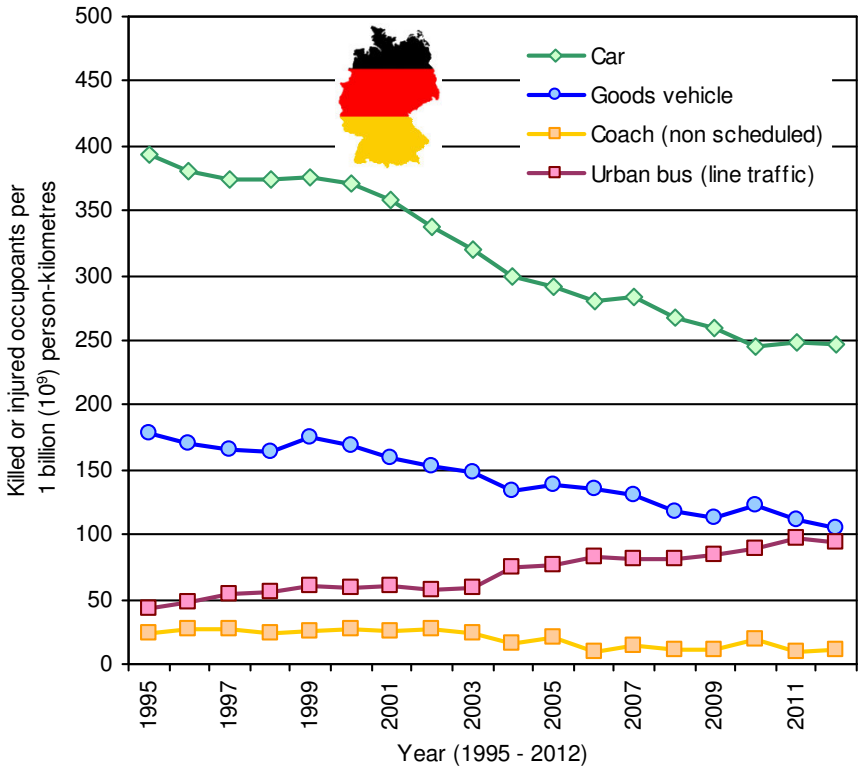


Figure 15:
Risk indicator values for occupants of urban buses, coaches, cars and goods vehicles calculated as killed or injured occupants per 1 billion person-kilometres for Germany from 1995 to 2012, Data sources: Federal Statistical Office, [3,5], Deutsches Institut für Wirtschaftsforschung DIW [10])



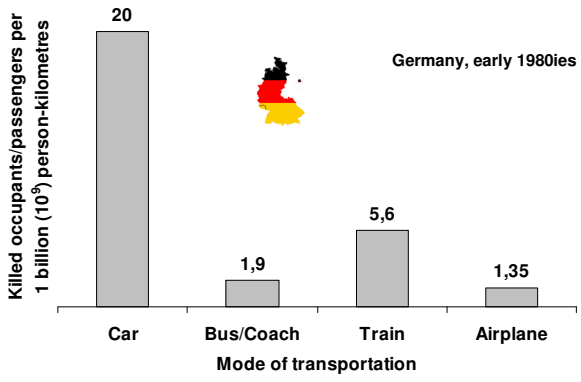
In earlier years these values of the fatality risk indicators related to transport performance for the occupants of cars and goods vehicles were still significantly higher than for the occupants of buses/coaches. As a consequence of the sustained evolution towards higher levels of safety for vehicles and road traffic as a whole, the values of the corresponding risk indicators for the occupants of these vehicles have almost approached that of the occupants of buses/coaches. For 2012 the values are 2.1 for car occupants and 1.6 for goods-vehicle occupants killed per 1 billion person-kilometres.

Concerning the casualty risk indicator values the graphs show significantly higher risks for car occupants despite the corresponding curve moved sustainably downwards. For 212 the calculated value is 248 car occupants killed or injured per 1 billion person-kilometres. The curve for goods vehicle occupants displays considerable decreasing indicator values as well. For 2012 a value of 105 goods-vehicle occupants killed or injured per 1 billion person-kilometres was calculated.

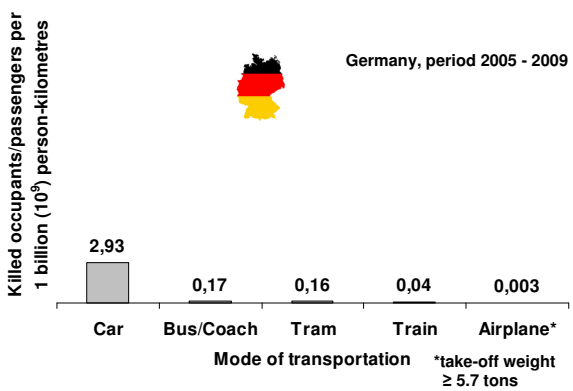
It is remarkable, that the risk of being killed or injured for the occupants of urban buses is growing whereas the corresponding risk for the occupants of coaches tends downwards. For 2012 the results are 94 occupants in urban buses and 11 occupants of coaches, each killed or injured per 1 billion person-kilometres.

General comparison of the fatality risk with other modes of long-distance travel

To compare the safety of buses with other modes of long-distance travel respectively public transport, from time to time there are official figures published displaying the fatality rates for the passengers of buses/coaches, trams, trains and airplanes with the risk of occupants (drivers and passengers) in cars. **Fig. 16** displays corresponding risk values for Germany reported by Langwieder et al. for the early 1980s [13] and by Vorndran for the period 2005 to 2009 [14]. First of all, the large reduction of the recent figures compared to the older ones is expressive. For example 1.9 bus/coach passengers have been killed per 1 billion person-kilometres in road accidents in the early 1980s. The corresponding risk-value for the period 2005 to 2009 is reduced by 99 % down to 0.17.



Source: Langwieder et al., 1985 [13]



Source: Vorndran, 2010 [14]

Figure 16: Comparisons of risk-indicator values related to killed passengers of buses/coaches, trams, trains, airplanes and occupants of cars, each per 1 billion person-kilometres for Germany in the early 1980ies and in recent years

As reported by Langwieder, in the early 1980s the risk value for car occupants (20) was 11 times higher that the value for bus/coach passengers (1.9). The figures publisehd by Vorndran displays that in the period 2005 to 2009 the risk-value for car occupants (2.93) is 17 times higher than tat for bus/coach passengers (0.17). For the early 1980s the values show that the bus is even saver than the train (5,6 killed passengers per 1 billion person-kilomteres) and on the same safety level as the airplane (1.36 killed passengers per 1 billion person-kilometres). For the period 2005 to 2009 the risk

values for buses/coaches and trams are with 0.17 and 0.16 on the same low level for both modes of transport and air travel is with a risk value of 0.003 clearly the safest mode of transport (for airplanes with a take-off weight above 5.7 tons).

Additionally, it is of interest how the risk values for car occupants alter when they are calculated separately for driver and passengers. As shown with re-calculated figures in **Table 7**, this separation indeed makes a remarkable difference. While 2.94 car drivers respectively 2.90 car occupants have been killed per 1 billion person-kilometres the corresponding value (based on the same value for the driving performance) is only 0.75 car passengers killed per 1 billion person-kilometres. But this value is still clearly higher (more than 4 times) as the value of 0.17 bus/coach occupants killed per 1 billion person-kilometres. Considering that not all car mileages are travelled with a passenger on board it becomes sure that for the passengers a bus journey is really much safer than a car journey.

Table 7: Risk-Indicator values calculated as killed per 1 billion person-kilometres for car occupants (driver and passengers) in Germany for the period 2005 to 2009 (Data source: Federal Statistical Office [4, 6])

Year	Killed car occupants			car transport performance [10^9 person-km]	Risk indicator values [killed per 1 billion person-kilometres]		
	drivers	passengers	occupants		drivers	passengers	occupants
2005	2,097	736	2.833	857,198	2.85	0.86	3.30
2006	1,987	696	2.683	859,428	2.85	0.81	3.12
2007	1,984	641	2.625	860,392	3.10	0.75	3.05
2008	1,742	626	2.368	849,624	2.78	0.74	2.79
2009	1,573	537	2.110	861,668	2.93	0.62	2.45
Mean value	1,877	647	2.524	857,662	2.90	0.75	2.94

CONCLUSUIONS AND OUTLOOK

To describe the safety of vehicles for their occupants (driver and passengers) some risk-indicators are in use. The interpretation of such indicators and their values differ depending on the data used for the calculation. It seems that for a complete view on recent figures and historical evolutions not only one indicator should be taken into account. This article gave some examples. All in all the statistics show very low numbers of bus/coach occupants killed or injured in road accidents with corresponding low risk indices. Although the safety of occupants of cars and goods vehicles gained on, the bus/coach is still the safest vehicle for the occupants (drivers and passengers) and especially for the passengers concerning travel on land.

Nevertheless, in view of the historic evolution and good results recently, the over-riding strategic aim is still valid to take appropriate measures to ensure first that the number of bus/coach accidents remains very low and second that the consequences of a serious accident, which can never be entirely eliminated, are kept to an absolute minimum.

Essential improvements were achieved in the active safety and as well in the passive safety of buses/coaches. From a technical point of view it can be stated that today's buses/coaches are safer than at any time before [15]. In the field of passive safety of coaches these measures become most effective when all occupants wear their seat belts throughout the journey. Since the belt use rate in coaches is still very low, the full safety potential of these vehicles could be even further exploited in the future if all occupants would use their safety belt during the journey.

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