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Evacuation from coaches

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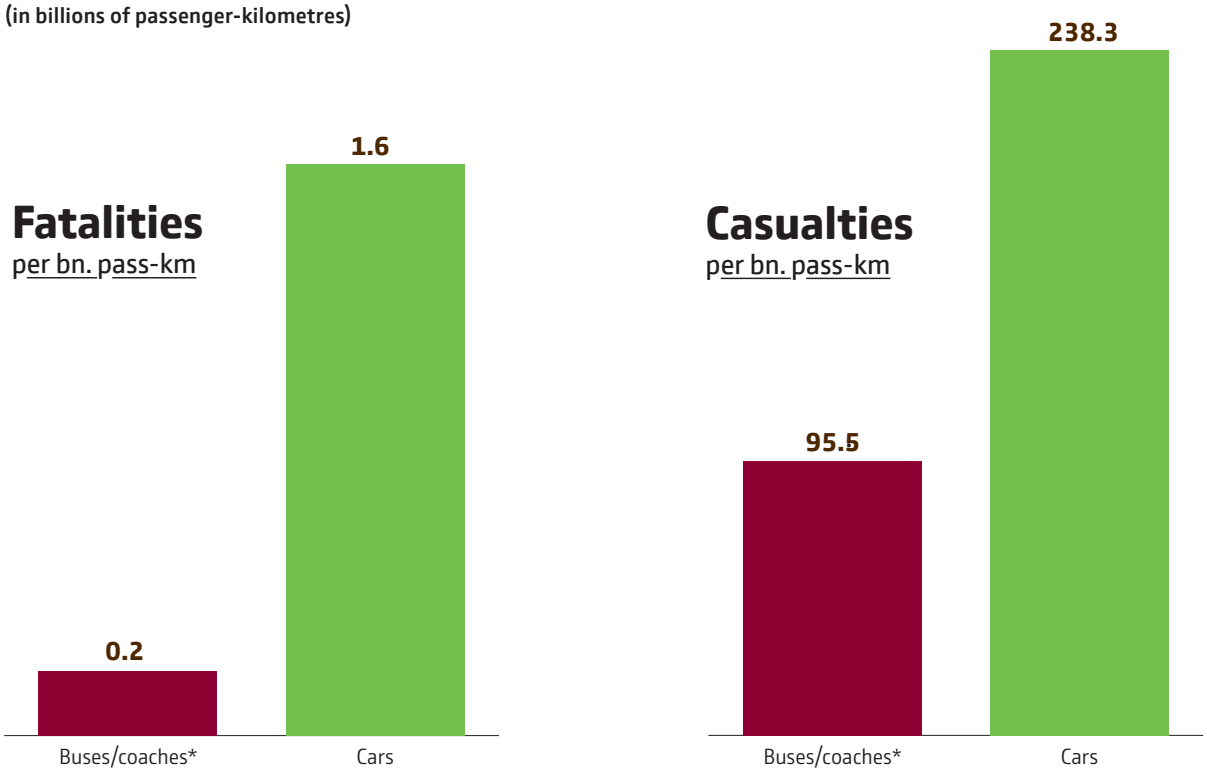
Introduction

Coaches are one of the safest means of land transport. Relative to their transport volume, which is specified in passenger-kilometres, that is to say the average number of kilometres driven by the vehicles multiplied by the average number of passengers transported, the number of occupants involved in accidents is significantly less than in the case of passenger cars (Figure 1).

Despite this, serious road accidents involving coaches do still occur. The liberalisation of intercity coach transport in 2013 is one of the factors that has brought about a significant increase in the number of journeys in this sector, in consequence, accompanied by an increase in the number of accidents involving coaches. In some of these accidents, occupants have also regrettably been severely or even fatally injured. For instance, in 2017, a rear-end motorway collision with a truck traveling in front in the same lane followed by the ensuing fire cost the lives of as many as 18 coach passengers (Figure 2).

Buses/coaches considerably safer than passenger cars relative to their transport volume

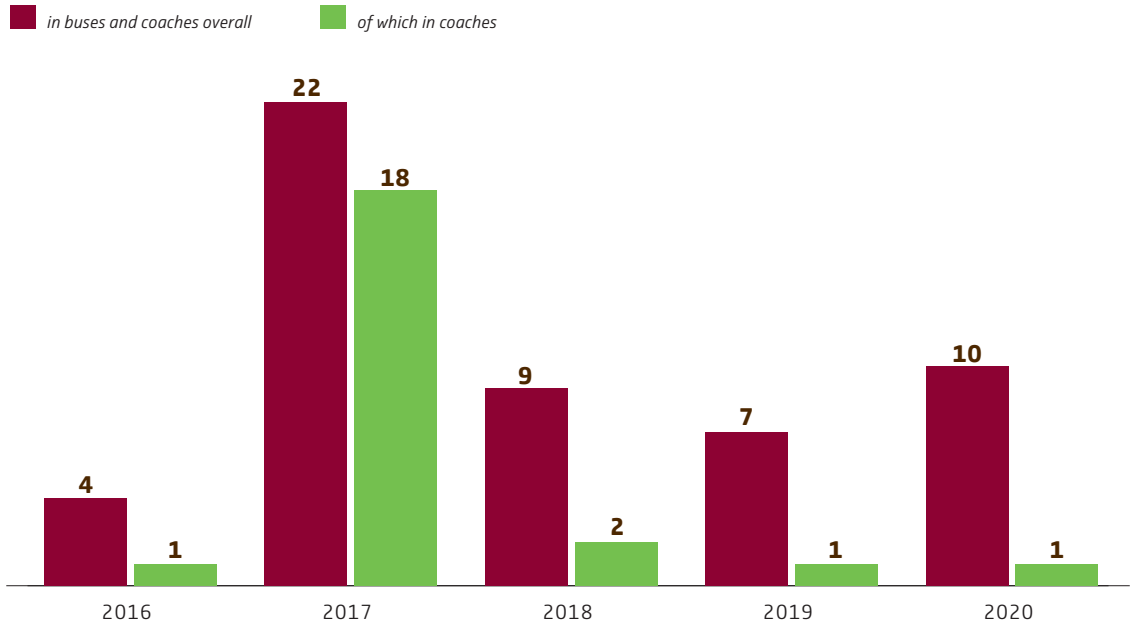
Figure 1 · **Average number of fatalities and casualties (occupants killed or injured) among bus/coach and passenger car occupants from 2016 to 2018, relative to the respective transport volumes (in billions of passenger-kilometres)**



** All coaches and buses including coaches, scheduled buses, school buses*
Source: Federal Statistical Office, Federal Motor Transport Authority, Mobility in Germany

Number of fatally injured bus/coach occupants per year in Germany usually in single figures

Figure 2 **· Absolute number of fatally injured bus/coach occupants in Germany, 2016 to 2020**



Source: Federal Statistical Office

Even though they are rare, it is necessary, when considering such accidents, to ask how significant numbers of casualties can be avoided in the future. In addition to measures designed to enhance active and passive safety, the evacuation of the occupants from the vehicle is another important aspect. This is all the more vital in cases where the severity of the collision itself causes no or only minor injuries among the passengers but the turning-over of the coach or a subsequent fire make it necessary to leave the vehicle quickly and without danger. It was in this context that the UDV (German Insurers Accident Research) launched the research project entitled "Evacuation from coaches" in which it was partnered by Trier University. The focus of the project was to critically examine the possibilities currently available for the evacuation and self-rescue of coach occupants and identify potential improvements. The project started with an analysis of past accidents and examined various phases of evacuation, unbuckling the seat belt, movement through and the guidance of occupants inside the coach, as well as egress through suitable emergency exits. To permit the evaluation of various concepts, trials were performed with test subjects under by-and-large controlled conditions. These concepts were first examined and approved by an Ethics Committee.

Legal requirements concerning evacuation

Regulation ECE-R107 [1] defines requirements relating to the design characteristics of buses and coaches of EU type classes M2 and M3 (vehicles with more than eight seats and a maximum gross weight of up to and including 5000 kg or a maximum gross weight of over 5000 kg). Alongside additional safety devices, including fire-extinguishing equipment in the engine compartment, this also relates to the number and type of emergency exits.

The minimum number of service doors and emergency exits depends on the design of the bus or coach and the number of passengers to be transported. The Regulation also defines the minimum dimensions of emergency windows and escape hatches. By contrast to the case of larger passenger aircraft, the carriages of passenger trains, and passenger ships, however, there are no specifications relating to the period within which it must be possible to evacuate the occupants.

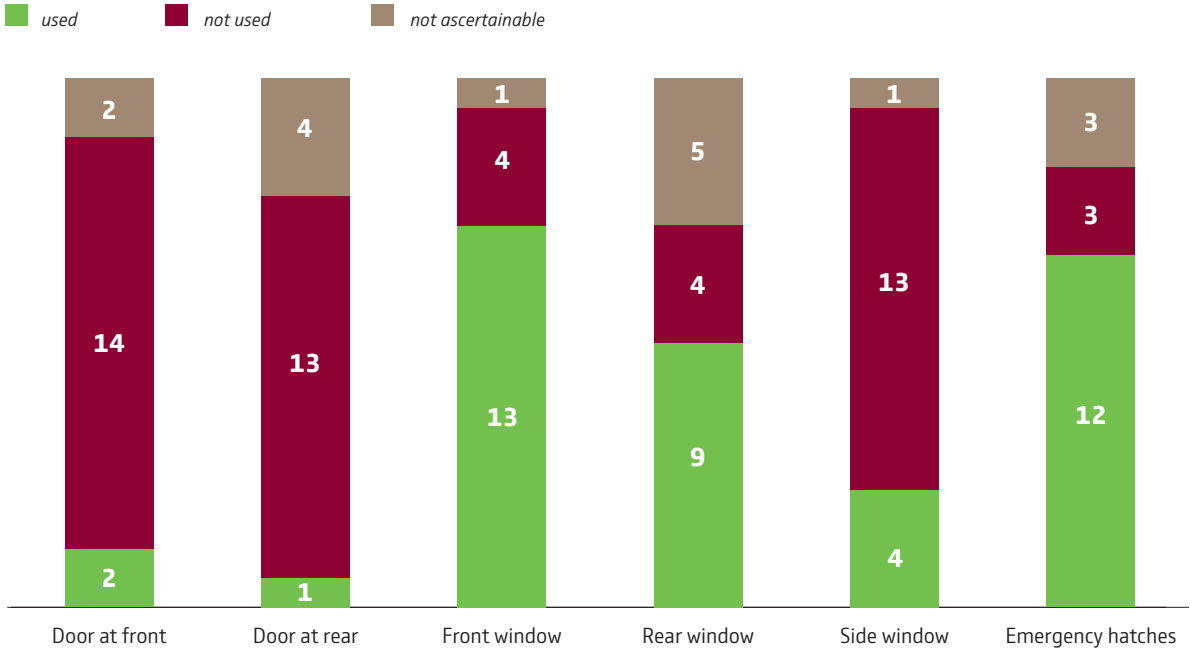
Analysis of the frequency and nature of accidents

To permit an assessment of the prerequisites for the rapid evacuation of a coach under realistic conditions, accidents occurring between 2010 and 2021 were searched for on the Internet and cases from the insurers' accident database (UDB) were also examined. The information was entered into a database set up for the purposes of the project and was analysed in consultation between the project partners. Of particular interest during this analysis was the number of casualties among the occupants and the severity of their injuries, as well as the final position of the coach after the accident and the areas that had suffered the most serious damage. This final analysis made it possible to identify which of the coach's normal service doors were still accessible and which emergency exits may also have been used. However, one limitation that should be mentioned is that it was not generally possible to determine which seats had been occupied by passengers, and in particular those who suffered injuries, at the time of the accident and which exits were used by the occupants at their own initiative. Rescue services often also make additional openings through side windows or the front window in order to gain access to occupants who are unable to escape by themselves. Apart from a few exceptions, vehicle fires fortunately did not occur following collisions. Approximately a third of the coaches involved in such accidents either ended up lying on the right-hand side or the service doors on this side could no longer be opened without difficulty due to collision-related deformations or the tilted position of the vehicle in a ditch by the side of the carriageway (Figure 3).

Figure 3 · Example damage profile with passenger doors that can no longer be used after the collision

The doors and side windows of coaches that have tipped over are rarely used

Figure 4 · **Number of emergency exits used in 18 coach accidents in which the vehicle ended up lying on its side (80° to 99°)**



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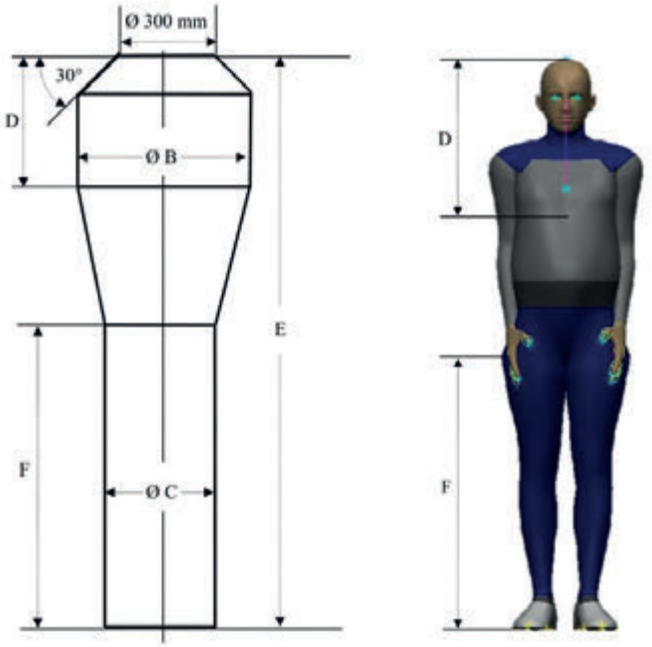
Of the 156 buses and coaches with a known vehicle design present in the case material, 112 were coaches or intercity buses (72 %). Research made it possible to identify the age and gender of 388 of the passengers. The distribution revealed that almost half of these (48 %) were children and young people aged up to 25 years and approximately one passenger in five (18 %) was a senior citizen aged 65 years or more. It was possible to determine the final position of 62 of the 112 coaches involved in the accidents. In 39 of the accidents, the vehicle remained broadly upright following the accident, whereas in five cases it came to rest in a tilted position (20 degrees – 39 degrees to the vertical) and in 18 cases it turned completely over onto its side. In twelve of these cases, the vehicle finally came to rest on its right-hand side, with the result that the service doors were blocked and passengers had to exit through roof hatches or the front or rear window. Figure 4 makes it clear that in cases where the vehicle came to rest on its side, the front window and roof hatches were primarily used in order to exit from the coach or for entry into the vehicle by the rescue services. By contrast, the rear window or side windows, which could theoretically also have been used as emergency exits, were used considerably less as exit routes.

Package studies

Even if the coach remains in an upright position, moving quickly inside it following an accident is by no means an easy task, even though this is essential for rapid evacuation. To ensure that vehicles are designed to permit passengers to pass along the central gangway between the rows of seats, Regulation ECE-R107 [1] defines minimum cross-sections which are verified using "gangway test gauges" which are intended to represent the extremely simplified profile of an adult human body. The bus and coach industry has also seen the emergence of digital simulation models (RAMSIS software) that make it possible to represent humans of different genders, age groups and body sizes together with

A "gangway test gauge" only provides an approximate representation of the geometry of occupants

Figure 5 · "Gangway test gauge" ECE-R 107 [1] compared to a simulated passenger (RAMSIS)



B: Shoulder width
C: Hip width
D: Breastbone to top of head
E: Body height
F: Crutch height

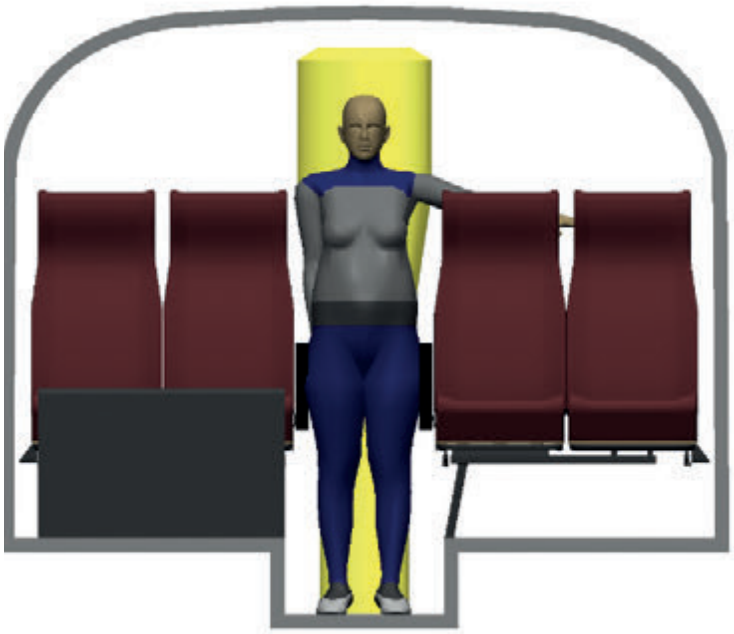
their space requirements, as well as their physical articulatory capabilities and their extremities (Figure 5).

However, a comparison of the principal dimensions of these digital representations with the gangway test gauges makes it clear that the latter are sometimes considerably smaller. In the "leg" area, the gangway test gauge is only 300 mm wide and therefore considerably narrower even than the RAMSIS representation of a 5% female at 329 mm and considerably more so than a 95% male at over 400 mm. At present, possibilities for the dimensioning of gangway widths in coaches in this way have mostly not been exhausted. If gangway widths were rigorously designed in accordance with the minimum requirements of ECE-R107 then the results would be that real passengers would only be able to move in the gangway with their hips facing sideways. Folding armrests at the seats also protrude into the cross-section of the gangway when raised, in particular in coaches whose central gangway is lower than the floor in front of the seats (Figure 6).

Movable seats are also often proposed for coaches. These make it possible to move the two inner seats in a row that flank the vehicle's central axis a few centimetres towards the central gangway in order to increase the distance to the outside seats during the journey and thereby increase seating comfort. However, this also further restricts the profile of the central gangway. In this case, the Regulation permits a residual gangway width of 220 mm instead of the original 300 mm. Following a collision, it is not to be expected that these seats will be pushed back into their original position after being vacated. Depending on the severity of the impact, it is also probable that the seat guides will be deformed and it will be impossible to push the seats back in again. If a number of these different influences occur in combination and if corpulent persons or persons of restricted mobility have to be evacuated, then it is obvious that the rapid passage of occupants along the gangway will be impeded.

Gangway width restricted by seat armrests

Figure 6 · Comparison of the hip width of a simulated woman (95th percentile) with gangway test gauge



Evacuation trials with the vehicle in a tilted position or on its side

If, in addition to the above-mentioned difficulties, the evacuation has to be undertaken after the vehicle has come to rest in a fully or partially tipped-over position then further challenges arise. To identify these and quantify them in the light of the available options, in-coach trials were performed with test subjects. The participants in these trials consisted of 73 persons with an average age of 32.5 years, most of whom were in good physical condition. Slightly more than half of them were male. To minimise the risk of injury and meet hygiene requirements, which were particularly justified in the light of the COVID-19 pandemic, it was not permissible to use experimental arrangements in which large numbers of participants were present in the coach simultaneously.

Evacuation trials with tilted vehicle

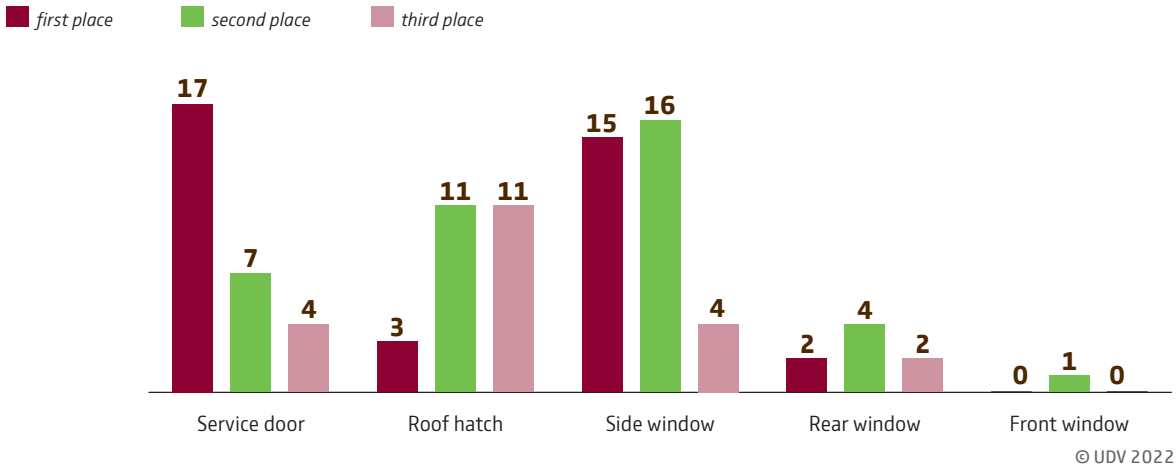
To this end, the coach was tilted by 30 degrees and secured in position. The 37 test subjects for this series of trials climbed into the coach individually through the front door by means of specially constructed steps. Their task was to pass through the central gangway and then exit the coach again through the rear door. Upon reaching the middle of the gangway, they had also been instructed to identify the nearest possible exit and then all the other emergency exits after this. After the trial, all the participants were given a questionnaire in which they were asked to rate their own physical constitution, evaluate their movement inside the vehicle and indicate suggested improvements. The simple pass-through times, i.e. without identifying the emergency exits, were significantly longer in the tilted vehicle compared to reference trials in an upright vehicle. The average time

Figure 7 · Example of a test subject moving through the tilted coach (30° inclination)

taken was 19 seconds, a value which tended to increase with greater age and reduced physical fitness. In most cases, the test subjects had to support themselves with their hands at the seat back and position their feet in the angle between the gangway floor and the adjoining edges of the raised seating area. This latter possibility is not available in coaches with level floors. In such vehicles, it would be necessary to deliberately position the feet at the floor anchorings of the seats, thereby increasing the risk of tripping or slipping. None of the participants used the luggage racks above the seats as hand rails. Accordingly, the test subjects reported that they would have appreciated the attachment of handles at the seats and luggage racks as well as the rounding of seat edges and a wider gangway. A number of persons also complained about a certain impairment of spatial perception due to the tilted "horizon" (Figure 7). When the vehicle was tilted, the side windows were almost always identified as a potential emergency exit, presumably due to their clear marking and the obvious provision of the emergency hammer. Many of the test subjects also identified the service doors, even though these can sometimes not be opened when the vehicle is tilted, and the roof hatch. By contrast, the rear window was only identified by a fifth of the participants (Figure 8).

Doors and side windows are the preferred emergency exits from tilted vehicles

Abbildung 8 · **Frequency and sequence in which various potential emergency exits were identified by 37 test subjects in a vehicle tilted at 30°**



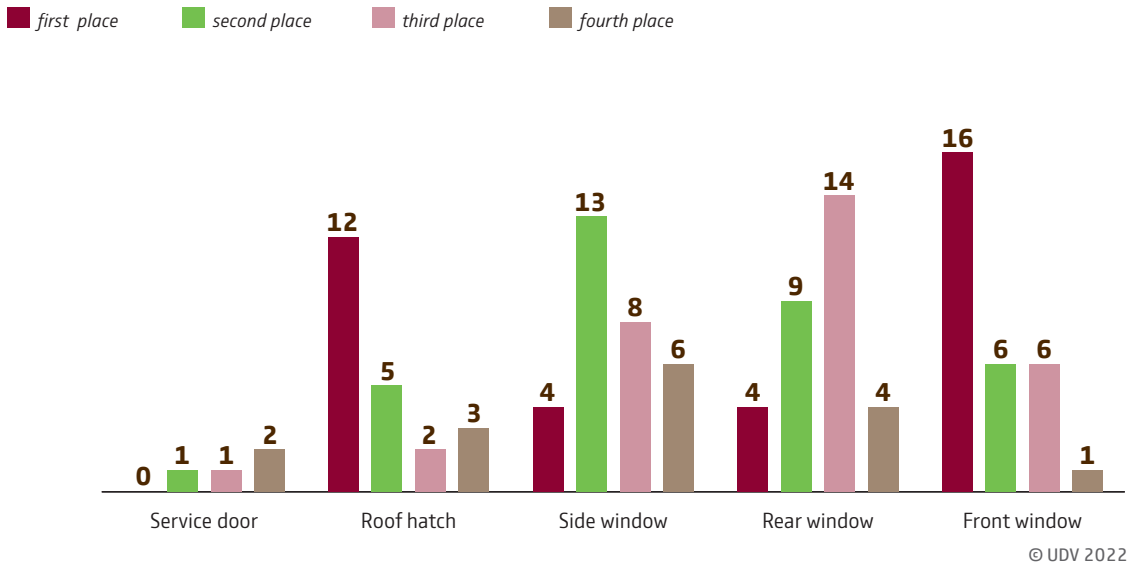
Evacuation trials with vehicle on side

For these trials, the coach was lying fully on its right-hand side, i.e. tilted through 90 degrees. The test subjects used ladders and access aids to enter the inside of the coach through the side window at the driver's seat and were again told to pass through the coach in the direction of the rear of the vehicle. Among other things, the questions of interest were whether the test subjects would identify the rear window and the roof hatches as available emergency exits and make use of these. In this coach model, it is necessary to fold the seat back of the central seat in the rearmost row of seats forwards in order to get to the rear window and unlock the roof hatches via a folding handle and move them to the side. 36 people took part in this series of trials. Compared to the slightly tilted position, most of the test subjects found it easier to pass through the coach, which they had to do along the area of the side windows between the top edge of the seat backs and the luggage rack. The times observed were similar to those measured when passing along the central gangway in upright position (Figure 9).

Figure 9 · Test subject moving through the tilted coach (90° inclination, lying on its side)

When the vehicle is lying on its side, the front window and roof hatch are the preferred emergency exits

Figure 10 · **Frequency and sequence in which various potential emergency exits were identified by 36 test subjects**



Despite this, additional handles and greater distances between the luggage rack and the seat backs were again considered to be of value. Some of the participants would have preferred to be informed in advance that it is possible to step on the side windows without danger. However, it was not possible to ascertain the extent to which the side windows would have been able to withstand the load of multiple persons. It should also be borne in mind that in the event of an accident causing the vehicle to tip over, the windows may be broken or at least have suffered some prior damage.

As expected, when the coach was lying on its side, the service doors were only identified as potential emergency exits by a few of the test subjects. Instead, the front window – which is, however, made from laminated glass and cannot easily be penetrated from the inside, even when using an emergency hammer – and the roof hatches were the first exits to be identified. These were followed in order by the side windows which, however, in this position were located overhead and would have been difficult to reach, and only then the rear window (Figure 10).

Several of the participants found it difficult to exit the coach through the roof hatch, which in the coach used for the trial was aligned in the habitual longitudinal direction, because of both the narrow passage height in this position and the height difference to the ground encountered on exiting (Figure 11).

Figure 11 · Different methods used by the test subjects to climb through the roof hatch with the vehicle turned (through 90°, lying on its side)

Hatchway evacuation trials through roof hatches

The problem that it is difficult to exit from a coach which is lying on its side was examined in greater detail using an experimental structure specifically created for the project. To this end, a coach section was constructed in the typical vehicle dimensions and with two complete rows of original coach seats. It could be moved into any required tilted position using an indoor crane. To further investigate the influence of the roof hatch geometry on evacuation, the situation in which the vehicle is completely lying on its side was again chosen and the roof hatch was represented in a simplified way as a rectangular opening with the dimensions of 800 x 600 mm, in accordance with the specifications set out in ECE-R107 [1]. Further trials with test subjects were run in order to analyse their climb-through behaviours and the times required. Two hatch openings with edges of the same lengths were compared. Hatches aligned along the longitudinal vehicle axis are standard in coaches. These were compared with a hatch aligned across the vehicle body, i.e. rotated through 90 degrees. At the start of the trial, the participant being tested had to position themselves in the "inside" of the tilted coach section in front of the hatch and climb through this as quickly as possible and using any strategy of their choice when called. After climbing through the hatch, the subjects were again given a questionnaire and were approximately measured, with the body size and leg length being of particular interest. The test subjects were subdivided into two groups of 37 persons each. The participants in the first group had to climb through a hatch aligned along the longitudinal vehicle axis, whereas those in the second group climbed through a transversally aligned hatch. The climb-through times were found to correlate with the age and weight of the test subjects, but not with their body size. The hatch aligned across the vehicle body – which presented a vertical opening when the vehicle was tilted and whose lower edge was positioned further down – was climbed through approximately 0.5 seconds more quickly on average than the longitudinally aligned hatch, which offered a reduced passage height and was at a greater distance from the ground. The test subjects accordingly judged the latter to be less convenient and more difficult to climb through (Figure 12).

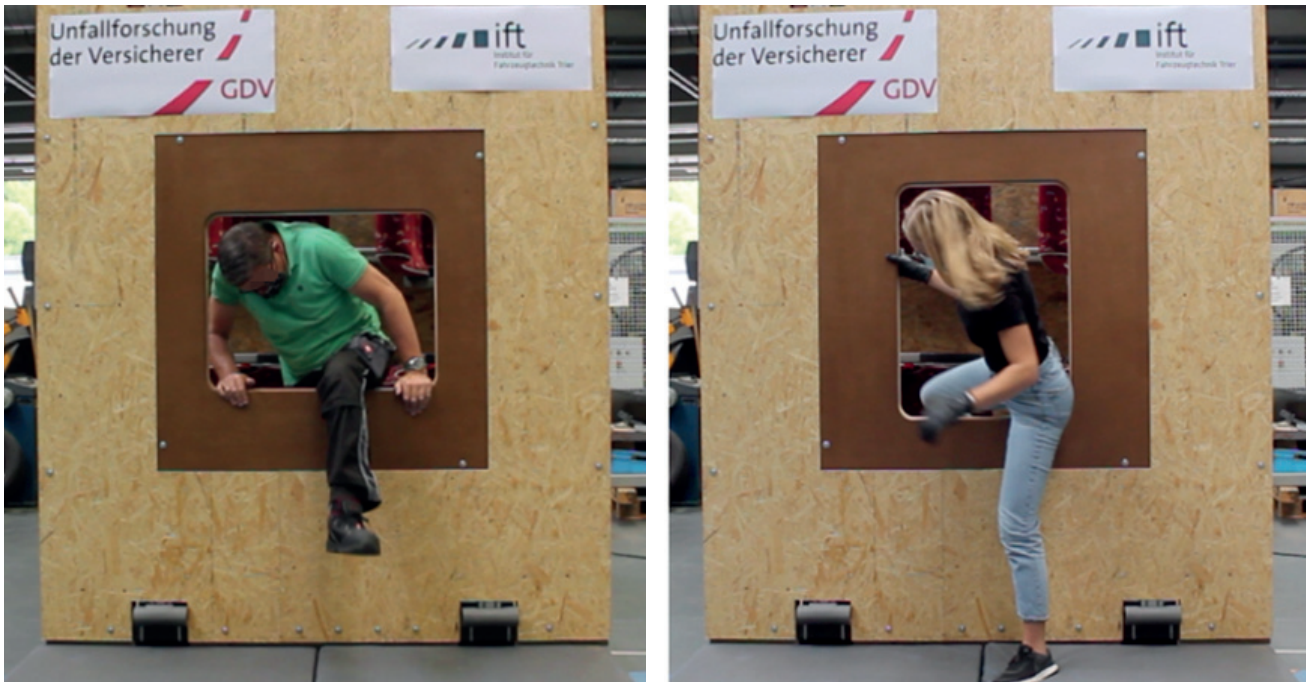


Figure 12 · Test subjects climbing through roof hatches aligned in the longitudinal and transverse directions

While the time differences measured in this laboratory trial may seem small, they can, on their own, add up to as much as half a minute when it is necessary to evacuate several dozen passengers from a vehicle lying on its side and this value can become significantly longer if – in contrast to the predominantly young participants who took part in these trials – older or less mobile passengers have to climb through the hatch. In reality, when tipped coaches are lying next to the carriageway, there is the additional problem that on uneven terrain, the vehicle is not in full contact with the ground surface and there is therefore an additional distance between the edge of the roof and the ground. Once passengers have climbed through the hatch, they must cope with an even greater height on the outside of the vehicle and this represents a further potential source of injury. It should also be noted that the roof hatches in modern coaches can often no longer be opened and pushed aside by hand but are designed as glass roof windows with rigid frames and have to be broken using an emergency hammer. Both the resulting fragments of glass and the remains of the pane that are left around the edge of the hatch represent further unnecessary sources of injury.

Seat belt unbuckling trials with tilted vehicle

If, following an accident after which the coach is inclined at an angle or has completely turned over, the passengers are wearing seat belts, as has been obligatory in coaches and intercity buses since 2006, then the occupants must be able to unbuckle their seat belts without assistance. To address this question scientifically, further trials were conducted with test subjects using the coach section and seating described above. The aim of this trial was to compare the ability of passengers to release themselves from two-point seat belts with automatic retractor of the sort generally found in coaches and from three-point automatic seat belts in vehicles that have tilted into an inclined position. Three-point belts have been the established solution for the occupants of passenger cars and other commercial vehicles for decades and are proposed as an option for some coach models. In this design, the top anchor point (so-called D-ring), through which the shoulder belt is guided, is integrated in the seat back. As a third seat belt variant, the belt system familiar from aircraft passenger seats, namely a

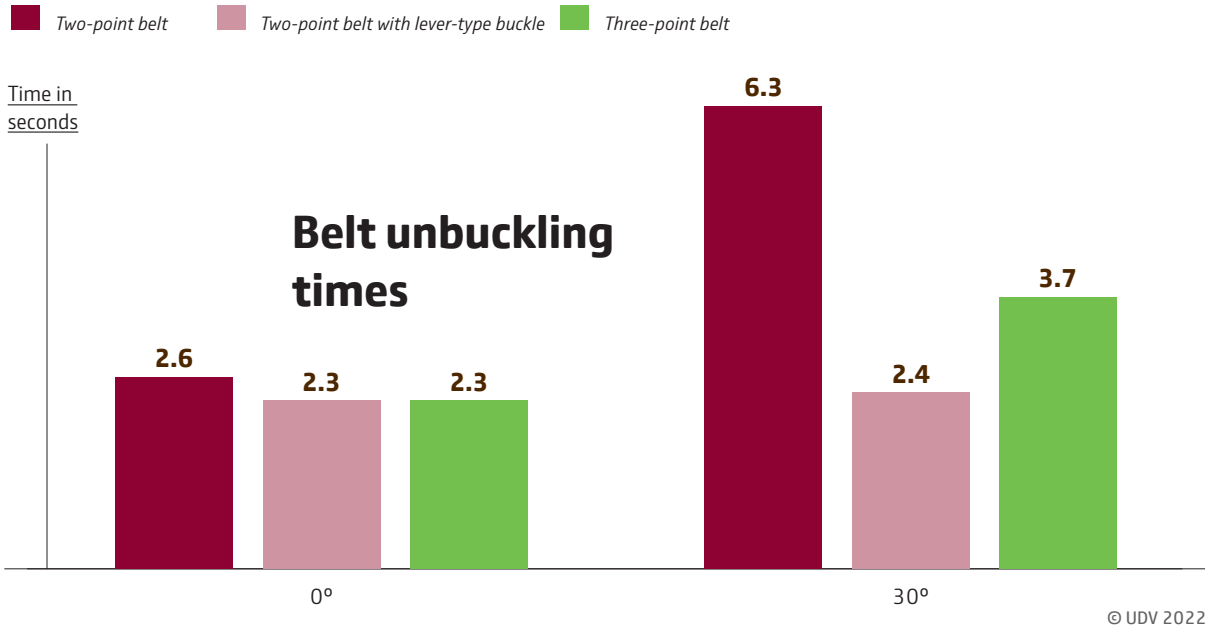
Figure 13 · Operation of the different belt systems at an inclination of 30° (top left: Two-point belt; top right: Two-point belt with central buckle; bottom: Three-point belt)

two-point static belt, i.e. without retractor and with a lever-type buckle, was included in the series of trials. Unlike the pushbutton systems used to unbuckle belts in automotive applications, the belt worn by the passenger here is released by lifting the lever on the buckle.

The 38 participants in the trials were asked to sit in one of the two inside seats, put on the seat belt, tighten it, remove it again and then rate the release of the locking mechanism. On the two-point and three-point automatic belts used in the automotive sector, the belt buckle was always located on the side of the seat next to the central gangway. The trials were conducted for all three belt systems in succession, first of all with one subgroup with the coach section in the upright position and then with the second subgroup with the coach section inclined at 30 degrees. The participants were assigned a seat on the immediate right of the central gangway. When the vehicle was leaning towards the left, this meant that the subject's hip slid in the direction of the central gangway and therefore over the buckle's pushbutton mechanism, making it more difficult to open the belt buckle. This generally required them to support their own body weight with one arm against a neighbouring seat in order to free the buckle on the left and operate it using their free hand. This proved to be somewhat easier with the three-point belt than the two-point automatic belt because the right hand was able to grip onto the shoulder belt if necessary. The fastest belt to unbuckle in an inclined position was the two-point static belt with centrally located lever-type buckle (Figure 13).

Conventional two-point belts more difficult to unbuckle after a coach accident

Figure 14 · Average times taken to unbuckle different belt systems with the coach upright (0°) and tilted through 30°



For the three-point automatic belts, the release of the pushbutton buckle was also examined when the test subject was sitting in the opposite seat on the left-hand side of the gangway. In this case, gravity caused the hip to slide towards the neighbouring seat, i.e. away from the central gangway, while the upper body was held by the shoulder belt, making it easier to access the belt buckle on the right. Consequently, participants sitting on a seat to the left of the gangway took less time to unbuckle the three-point belt in a tilted vehicle (Figure 14).

If the coach were to tip to the right, then the prerequisites for releasing belt systems would be inverted depending on the respective seat position of the belt buckle. Only in the case of the two-point static belts with central lever-type buckle would this have no influence on operation.

However, these considerations should not overshadow the fact that the main task of the seat belt is to restrain the passenger safely in the event of a collision and, in the case of coaches, in particular when the vehicle tips or rolls over. Two-point belts with automatic retractor should be preferred to the static belts used in the aviation industry, even before addressing the uncertain question of whether the latter are suitable for certification in the automotive sector. However, not only are the two-point automatic belts in turn surpassed by three-point automatic belts in terms of passenger safety, but the latter were also considered to be more comfortable to wear and easier to operate by the participants.

Improvements to the evacuation capabilities

The trials involving test subjects presented above showed that passengers in no way always identify the closest suitable emergency exit when faced with the task of exiting from a coach via the fastest possible route. To demonstrate measures that might potentially make it possible to address this problem, a prototype light guidance system was developed and implemented. To this end, a coach was equipped with a dual light chase (LED light strips) at the luggage racks – that is to say, at eye-level for a standing passenger. A side window which had previously been defined as a suitable emergency exit

was also equipped with flashing lighting. Eleven test subjects wearing eye-tracking glasses which made it possible to track their eye movements were first individually positioned at a seat in the front part of the coach. They were then unexpectedly told about a fictitious accident and asked to designate the closest emergency exit. At the same time, the light chase circuit was activated and controlled to indicate a direction of movement toward the rear of the vehicle. In addition, the previously defined emergency exit was also indicated by means of a flashing light. In response to this event, all the test subjects directed their view backwards and named the identified emergency exits correctly.

The analysis of the frequency and nature of accidents had already shown that normal service doors may be blocked or jammed during an accident. Side windows and roof hatches are only of limited suitability as emergency exits or are not recognised as being such by passengers. Consequently, future developments to improve evacuation capabilities should place an increased focus on the rear and front of the coach.

Although the rear window is already intended to provide an emergency exit in many coaches, its use is often unnecessarily hampered in practice. Because coach travel is also intended to be attractive for persons departing on activity holidays, coaches are often equipped with additional transport boxes at the rear, for example to accommodate skiing equipment or to transport bicycles. It has been repeatedly observed that such additions partly or completely cover the rear window and consequently block the emergency exit. Alongside the coach and vehicle accessories industry, it is also the responsibility of the coach operator to ensure that no such restrictions occur during operation.

As the trials and the questionnaires given to the test subjects suggest, passengers also consider the front window to be a suitable emergency exit, presumably not least because of its size and because it is continuously visible to passengers during the journey. At present, however, it cannot be used as an emergency exit by the coach's occupants because it is made from laminated safety glass and is generally bonded to the window frame in order to increase the structural strength of the coach design. In the future, it would therefore appear necessary to pursue concepts that make it possible to open the front window from the inside in the event of an accident, for example by activating built-in pyrotechnic charges that separate the window from the frame: This is a technology that is primarily also used in the field of special protection vehicle construction [2]. On the one hand, this would create a very large opening and, on the other, even when the coach remains upright, the distance down to the ground when exiting from the vehicle would be relatively small. If alternative drive systems based on the use of stored electrical energy, gas or hydrogen become increasingly prevalent in the field of coach design, then the roof area will be occupied by energy storage equipment or control and power electronics and there will be hardly any space available for sufficiently large roof hatches. By this point, at the very latest, the use of the rear and front windows as emergency exits will become an urgent necessity.

Conclusions and requirements

Whereas recent years have seen considerable accident prevention efforts in the field of coach design through the mandatory introduction of driver assistance systems, work on improving evacuation capabilities following an accident, i.e. in the field of "post-crash rescue", is still lagging behind. In this context, it should also be noted that the rapid evacuation of passengers may also be necessary if a fire occurs in the vehicle without any previous collision. In the case of a fire, in particular, it is vital to be able to exit from the vehicle as quickly as possible. It would therefore be useful for the design of emergency exits, for example in terms of their number and cross-sectional area, to have guidelines based on those used in the aviation industry combined with specifications regarding the time per passenger or the period required for full evacuation.

To reach doors or emergency exits quickly, it is essential to be able to move unimpaired in the coach. This must also be possible for corpulent or older people, which is why an adequate gangway width is vital. The standards must take account of this in the form of more realistic specifications. It must be easily possible to return seating elements that protrude into the gangway, such as armrests or seats that can be moved sideways, to a position that does not impede passage through the central gangway.

In approximately one third of all serious coach accidents, the vehicle turns over completely or comes to rest in a tilted position. To permit movement through the vehicle in such cases, surfaces at the edge of the central gangway should ideally be provided where passengers can position their feet securely, along with handles on the seat backs which they can hold onto. If the coach is in a tilted position or has turned over to the right, then the normal service doors can no longer be used. When a vehicle is lying on its side, the roof hatches that are provided as emergency exits are not usually arranged in a way that enables them to be climbed through quickly and safely. In modern coaches, their glazed areas must also first be broken, consuming additional time and creating an unnecessary risk of injury due to glass fragments. In the future, therefore, roof hatches should be aligned transversely to the direction of travel and it must be possible to open them without danger and the need for additional equipment. If the side windows or rear window are intended to be used as additional emergency exits then, in addition to clear identification and simple instructions about how to open them, the development of further visual aids such as light chases should be pursued in order to guide passengers to the appropriate emergency exit if evacuation is necessary. So far, it has not been possible for persons inside the bus to open the front window. However, it would be well accepted as a potential emergency exit and would offer an incomparably large cross-section permitting fast and comparatively safe evacuation of the vehicle. In new coach development projects, it is therefore also necessary to take account of this potential emergency exit.

Coaches must be equipped with seat belts at every seat. Although many passengers are still regrettably reluctant to wear these, it is nevertheless a prerequisite in order to remain secured in one's seat in the event of a serious collision and, in particular, if the vehicle tips or rolls over. In addition to playing this protective role, belts should also be as easy as possible for passengers to remove once the vehicle has come to rest. If the vehicle ends up tilted at an angle or lying on its side, then occupants may sometimes find it impossible to activate the belt buckle of two-point automatic belts such as those installed as standard at passenger seats. Three-point automatic belts not only outperform the latter in terms of effective passenger restraint during the accident itself, but also allow easier access to the belt buckle so that passengers can free themselves. In addition, the questionnaires showed that users also prefer these to the two-point automatic belts in terms of comfort. Coaches for the North American market are optionally available equipped with three-point belts [3], [4]. Coach manufacturers and operators should therefore not shy away from the additional costs involved in also installing three-point belts for the European market given the improvement in passenger safety they provide.

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References

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