Safety of Busses and Coaches: Current Situation and Priorities for Future Researches

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Abstract: This paper reviews accident data concerning the safety of busses and coaches to determine the priorities for safety improvement; it will also analyse recently completed and on-going research projects in this area. A special attention is made to the transport of standing passengers, the effectiveness of restrain systems in coaches, the pedestrian protection through active and passive safety solutions, especially for buses in cities, the value of new technologies to help the driver in difficult situations, in relation with the tasks he has to accomplish and to the transport of handicapped passengers (adults and children) in busses and coaches. Based on this analysis, this paper discusses priorities for future researches, and proposes some themes of future projects

Keywords: bus; coach; safety; restrain systems; pedestrian protection

1. Some Definitions

It is generally accepted that coaches and buses are vehicles used for public transport of passengers which are designed to carry more than 9 passengers.

Coaches are used for long distance transport, mainly between cities, and all passengers are seating.

Busses transport passengers within a city; their occupants may be sitting or standing.

In Europe there are more precise definitions of road vehicles aimed at transporting passengers according to their size and their use.

Definition related to size:

M1: 8 passengers (9 occupants including the driver) or less; they are also called minibuses and generally occupants are seating.

M2: more than 8 occupants (or 9 passengers including the driver) and weight below 5tons (typically small and medium city busses).

M3: more than 8 occupants (or 9 passengers including the driver) and weight above 5tons (typically coaches and large city busses).

Definitions related to use:

Class I: Mainly standing passengers (typically city busses).

Class II: Mainly seating, standing allowed (typically city/suburban busses).

Class III: Seating only passengers (typically coaches).

2. Accident Data

As indicated on figure 1, bus and coach occupants represent a small percentage of the total number of traffic accident fatalities in Europe and it is generally considered that it is about 8 times safer to travel by bus or coach than by car (1); some of coach accidents can result in a large number of fatalities in a single accident, and the constant development of bus and coach transport would also increase the number of bus and coach accidents.

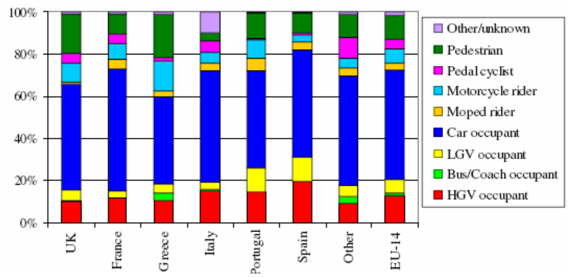

Figure 1. Fatalities in Traffic Accidents in Europe

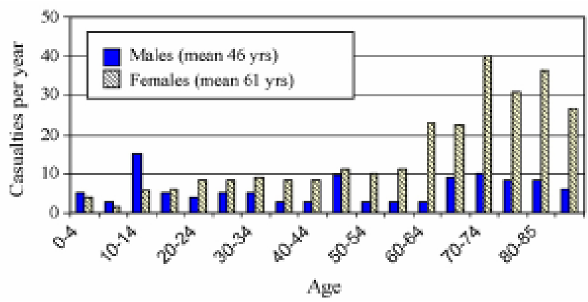

Figure 2. Age and gender distribution of standing passengers injured in non-crash incidents

In Europe every year about 20000 bus and coach accidents happen (4% of the total number of traffic accidents), they result in 35000 occupants injured and 250 killed.

About 60% of injured bus and coach occupants sustain their injuries during non crash incidents, i.e; braking, turning, acceleration, or when entering or leaving the bus; among them 1/3 are injured as standing passenger falling during a bus acceleration/deceleration (2).

As indicated in figure 2, the risk of falling for a standing passenger increases with age especially for female for which this risk is three to five times higher compared to male passengers, when they are over 50 years old.

The most frequent situations in which a bus or coach occupant sustains injuries are when he leaves the vehicle, followed by boarding; inside the vehicle more standing occupants than those seated are injured, but seated occupants are more likely to sustain fatal injuries. The latter relates to severe coach accidents in which all occupants are seated.

Based on U.K. analysis, pedestrians killed or seriously injured as being hit by a bus are almost as many as injured bus occupants, but the social cost of pedestrians is 45% higher than the cost of occupants. This can be related to the agressivity of bus and coach structures, in the absence of regulation for pedestrian protection. The same study shows that 63% are hit by the front of the bus, and collision with opposite side is almost 6 times more frequent than collisions with driver side (28% versus 6%); the remaining (3%) involve the rear of the vehicle in back up manoeuvre.

In Europe more and more coaches are fitted with two point safety belts and it is compulsory to wear then. A study based on 20 coach accidents involving 753 unbelted passengers (with almost half of them being injured) shows that about 75% of them would have been less injured if they were wearing a two points safety belt (3).

3. Results of Recent Researches

Compared to car safety, there is much less research projects related to bus and coach safety. Several research projects are dealing with pedestrian safety when hit by a bus; as indicated previously this is an important topic.

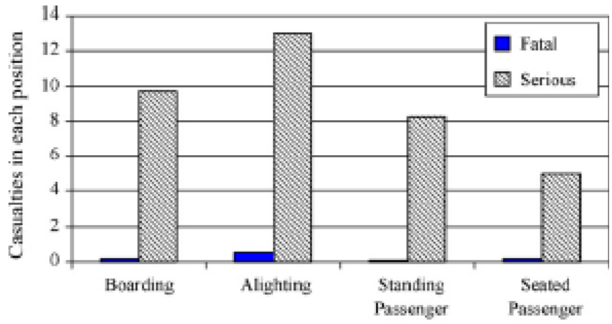

Figure 3. Situations producing severe and fatal injuries to bus and coach occupants

Table 1. Importance of pedestrian hit by a bus or a coach

User type	Number of KSI	Cost (M€)
Bus occupants	1351	100
Pedestrians hit by a bus	1204	145

A recent research project considered the possibility of detecting pedestrians when being in a zone where there is a high risk of conflict with a bus (4). This research has demonstrated that using fixed cameras in areas were the risk is higher, such as road crossing with bus turning, or bus stops, is more efficient than on board cameras. Figure 4 shows an example of a set of fixed cameras installed in a rood crossing aimed at alerting the bus driver if there is a risk of collision with a pedestrian.

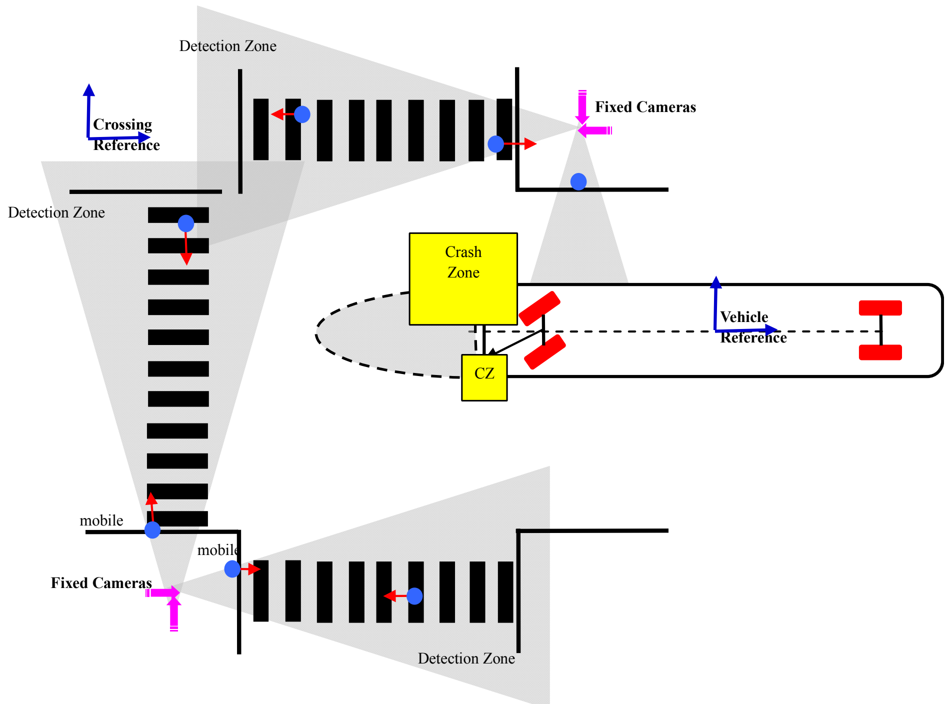

Figure 4. Example of a set of fixed cameras for pedestrian detection

The driver cannot watch continuously the screens shoving the images of the cameras, and then in complement to the cameras, the system has to include an expert system, analysing the images of the cameras aimed at predicting the risk of collision in real time, and alerting the driver when the risk is over a threshold level. The advantage of fixed cameras is that they are easier to calibrate for risk assessment, and in a city the areas where the detection of pedestrian is needed are not too difficult to identify.

There are very few projects aimed at improving passive of buses and coaches in cas of collision with a pedestrian.

The most relevant project, called Prudent VI (5), investigates the possibility to design a bus front face less aggressive to pedestrian. The project first evaluated the stiffness of different areas of the front face in pedestrian impact conditions as indicated on figure 5.

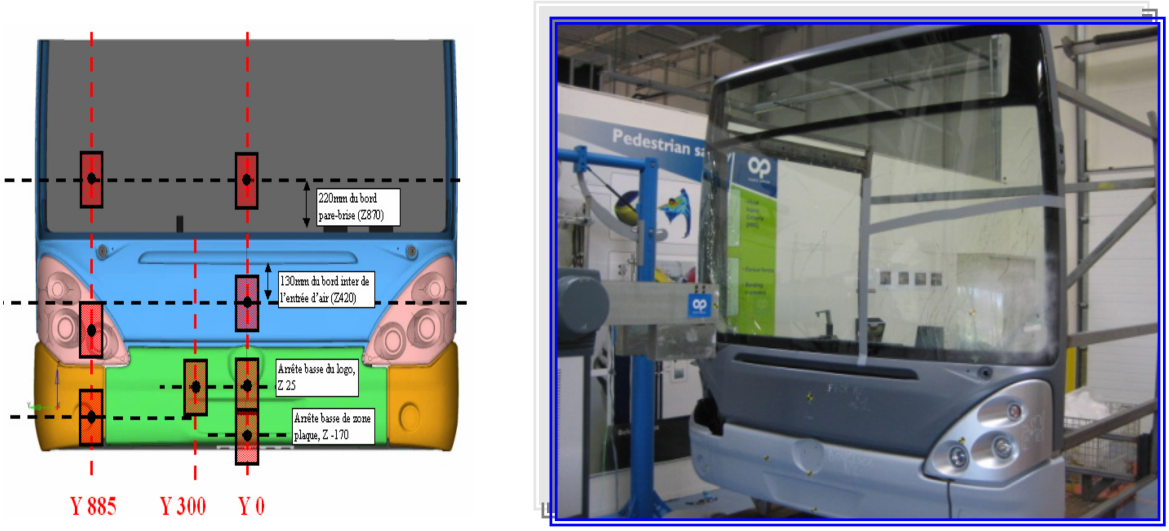

Figure 5. Areas tested for pedestrian protection improvement

This evaluation was completed by dummy tests involving the same components of the bus front face. These tests show the importance of head and leg protection, similar to car impacts, but also the importance of thoracic injuries unlike car impacts.

Leg restrain depends directly from the geometry of the front face, especially too high lower bumper level would allows the pedestrian legs going under the bus corresponding to a high bending moment applied to the legs. In case of child pedestrian, this would produce a kinematic pushing the child forward to the ground, with a high risk of being run over by the bus.

This project also looked at the materials characteristics to improve pedestrian protection; this concerned the choice of the materials but also their dimensions to optimise energy absorption capabilities.

Several projects looked at compatibility between bus and car in frontal collision, and as for trucks it is proposed to fit the lower of the front face with an energy absorbing front underrun protection (EAFUP), as shown on figure 6.

More recent projects dealing with bus and coach favour a systemic approach combining the functions assessed by the new technologies and their use by the drivers in relation to human capabilities to perform several tasks at the same time (6). This is a very important issue, as if the technology performance has in principle no limits, human performance is limited and almost cannot be changed, except for a small amount through training programmes for professional drivers.

Figure 6. Front underrun protection for bus

4. Conclusion

To conclude it is important to remind that even if travelling by bus or coach is safer than being a car occupant, safety of bus and coach needs to be improved for the driver, the passengers and the pedestrians. This need to do more applied researches and these researches require more in depth accident data.

The difficulties of the problem support the need of international cooperation in this area especially for accident studies.

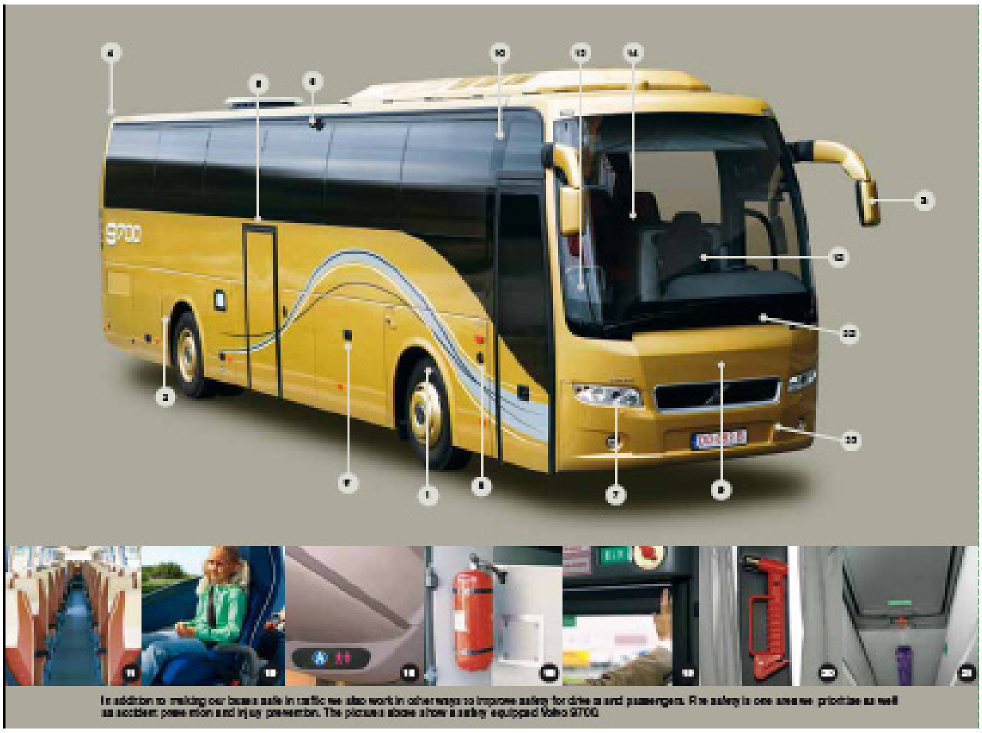

Figure 7. Technologies aimed at improving coach safety (1 Electronic Disc brake &ESP, 3 + 4 《All around》rear view, 19 + 21 Emergency exits, 12 to 16 Restrain systems, 23 Front underrun, 10 Rollover protection, 6 + 7 Improved lighting, 11 + 22 Interior protection, 18 to 21 Passenger evacuation)

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