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Professional paper

ANALYSIS OF THE PASSENGER CABIN AT A PASSENGER BUS FROM THE ASPECT OF CHARACTERISTICS OF PASSIVE SAFETY

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Abstract

If the elements in charge of active safety in the vehicles participating in road traffic are those, whose aim is to minimize the possibilities for occurrence of a traffic accident, such as a series of electronic systems in charge of the handling and stability of the vehicle in all conditions of movement (ABS, ASR, ESP systems, etc.), features and passive safety systems should minimize the consequences of the accident, primarily in terms of preventing endangerment of the body and life of the driver and passengers in the vehicle. In addition to all the passive safety systems installed in the vehicles for the protection of the driver and passengers, such as seat belts, airbags, the way of designing the elements inside the passenger compartment of the vehicle, which should prevent possible injuries in a case of impact, chassis, self-supporting structures and bodies of vehicles, should be performed with more deformable zones. The purpose of these deformable zones is to accumulate (absorb) as much as possible the kinetic energy of the impact, so that the deformations would not reach the passenger cabin, i.e. the space in which the driver and passengers are accommodated would remain undeformed, and thus the space for the survival of passengers would be saved.

The purpose of this paper is to analyze the structural features of the body of vehicles from the point of view of passive safety, with special reference to the passenger bus in terms of preserving space for passengers in overturning and some other features of passive safety in charge of injury protection of passengers in the passenger compartment.

Keywords: Rollover, Bus Structure, Residual Space,

1 Introduction

When we talk about the safety features of motor vehicles in general [1], we mean that a safe vehicle is the vehicle that with all its functions to the least extent possible affects the causes of traffic accidents, as well as the magnitude of the consequences that occur as a result of the accident, which should be as small as possible. Speaking of the broader concept in terms of vehicle safety in traffic, it is more than clear that the vehicles participating in road traffic during operation are practically a potential danger to people, vehicles and the environment in which traffic takes place. Hence, having in mind the broad definition of motor vehicle safety in road traffic, there are a huge number of parameters that provide the opportunity through their design and construction, to provide opportunities to increase the safety and security of vehicles.

However, this refers to vehicles which are in good condition, vehicles whose systems, subsystems and components are in good working condition. This would mean that the general definition of safety features does not exclude the broader aspects of safety, which arise from the malfunction of certain units, devices and systems, such as propulsion engine, clutch, gearbox, suspension and braking systems, steering system, etc. Of course, these are malfunctions that greatly impair the safety of the vehicle, but they are not the result of the design and construction of the vehicle, but fall solely on the conscience of the driver [1]. As such, these defects can not be quantified and evaluated, because they are exclusively dependent on the entity (driver) who does not service and maintain the vehicle properly, i.e. consciously accepted to drive a malfunctioning vehicle and thus endangers the flow of traffic to a large extent.

Starting from the general definition presented above and systematizing the safety features resulting from the design, construction and performance of the vehicle as a whole and its subsystems, according to their specifics, safety features can be grouped into three basic groups [1]:

Characteristics of active safety, which are characteristics that cover all those parameters that directly affect the possibility of a traffic accident;

Passive safety features, these are all those features that cover the parameters that affect so that even when the vehicle suffers a traffic accident, with its construction and the construction of its devices, systems and their placement, will allow minimal or even no injuries to passengers in an accident;

Catalytic safety features, which include the parameters that could indirectly contribute to the occurrence of an accident or increase the consequences of the accident.

Passive safety characteristics apply to all devices and systems incorporated in the vehicle which are designed and constructed to affect the consequences of an accident in any way. At the same time, the most important are those devices and systems that with their performance first protect the passengers, and then act in the direction of reducing the damage to the vehicle, but also to the other participants in the traffic [1]. Among the other features that are important for increased passive safety, of course, is the method of construction and production of the chassis and the body of the vehicle. The body of the vehicle should be constructed, designed and produced in such a way, that in the event of a collision with another vehicle, and in case of overturning the vehicle, to provide sufficient undeformed space, in which the driver and passengers would remain unharmed [1]. In this sense, the way that the engine connects with the chassis in the event of a collision results in the engine receiving a significant amount of energy from the impact and makes it fall out in a way that will not penetrate into the cab of the vehicle, and thus the cabin space at the feet remains undeformed [1]. The body of the vehicle should be made with special deformable zones which, in the event of a collision with another vehicle or other solid object, would receive a significant part of the kinetic energy of the impact and would allow the cab with the driver and passengers to remain undeformed (at best case) or, even after its deformation, in the passenger compartment to make sure a sufficient space remains for the survival of the passengers with as small consequences as possible for their health.

2 Vehicle body design as an important element of passive safety

In this regard, in terms of bodywork to meet the above requirements, Figures 1 and 2 [2] show examples of CRASH TESTS according to EURO NCAP, which clearly shows the importance of bodywork in preserving the integrity of the passenger compartment, and thus the preservation of life and the reduction of injuries to the driver and passengers. On the left and right side of Figure 1 can be seen the damage to the body and the condition of the passenger cabin during good and bad performance of the body, in conditions of identical crash test.

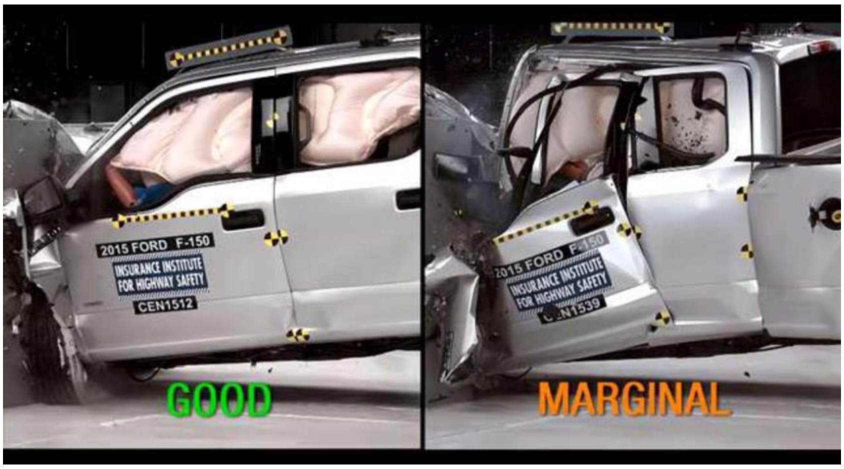

Figure 1. The condition of the passenger cabin after a head-on collision [2]

According to what can be seen in Figure 1, in the case of the vehicle shown on the left side of the figure, after the collision process, the integrity of the space for the driver and passengers (passenger cabin) is retained, and thus the passenger survival space, unlike the vehicle shown on the right side of the picture where can be seen intense deformations of the body, but also a large deformation and disturbance of the passenger space.

Figure [2] refers to Crash TEST performed under the same conditions, on vehicles of the same brand, but for different car markets. This picture also clearly shows a huge difference in the deformations and preservation of the integrity of the passenger space in the vehicles under the appropriate conditions of the collision process. In the first case (on the left side of the picture) it is clearly seen after the collision, the passenger cabin of the vehicle is fully preserved (thus fully saving the passenger survival space), while in the second case (right side of the picture 2), there is major damage and deformation of the passenger compartment, i.e. a large reduction of the passenger survival space.

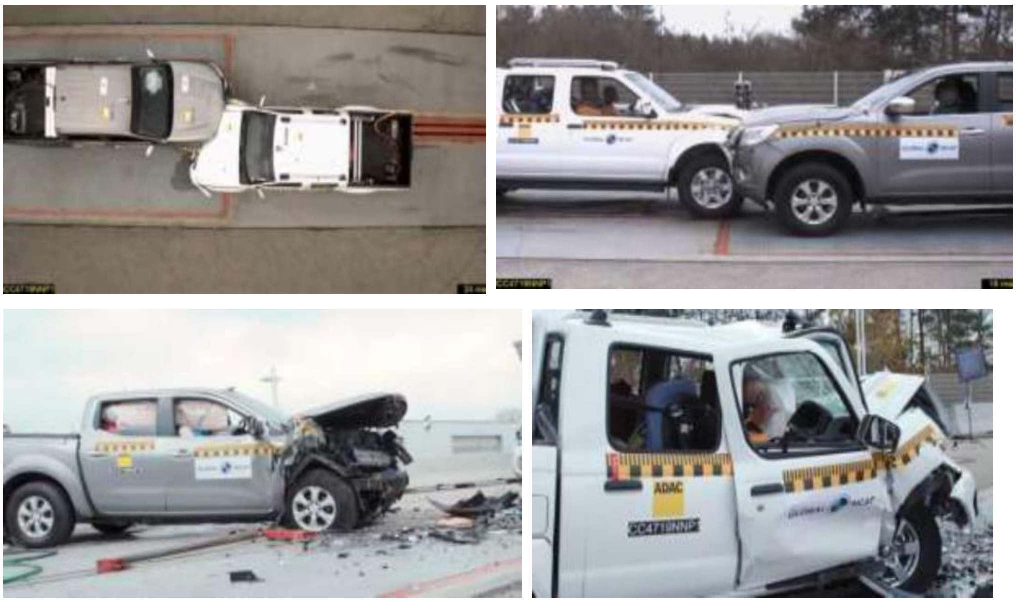

Figure 2. Crash test of new vehicle NISSAN NP300 Hardbody and used NISSAN NAVARA NP300 [2]

Having in mind the importance of the performance of the body of the vehicles in minimizing the consequences of traffic accidents on the passengers of the vehicle, and as stated in the introductory part, within this paper will be made an analysis of the design and performance of passenger space for passenger bus in terms of passive safety features.

3 Test Analysis of the structure in a rollover bus according regulative ECE R 66

The European Economic Commission for European Regulation (UNECE) under the auspices of the United Nations in 1986, for the first time adopted the regulation ECE R66 [5] in order to protect the residual space, i.e. the passenger survival space (Survival Space) which should be strong enough to provide maximum occupant protection in the event of an accident when a bus overturns. The ECE R66 regulation introduces the strictest criteria in terms of improvement, i.e. improvement of the structure of the buses through the use of better materials that are stronger and more durable, lighter in weight, and have a high ability to absorb kinetic energy (aluminium, etc.) so that during the overturning of the bus they will completely enclose the passenger survival space (Survival Space) - Residual space.

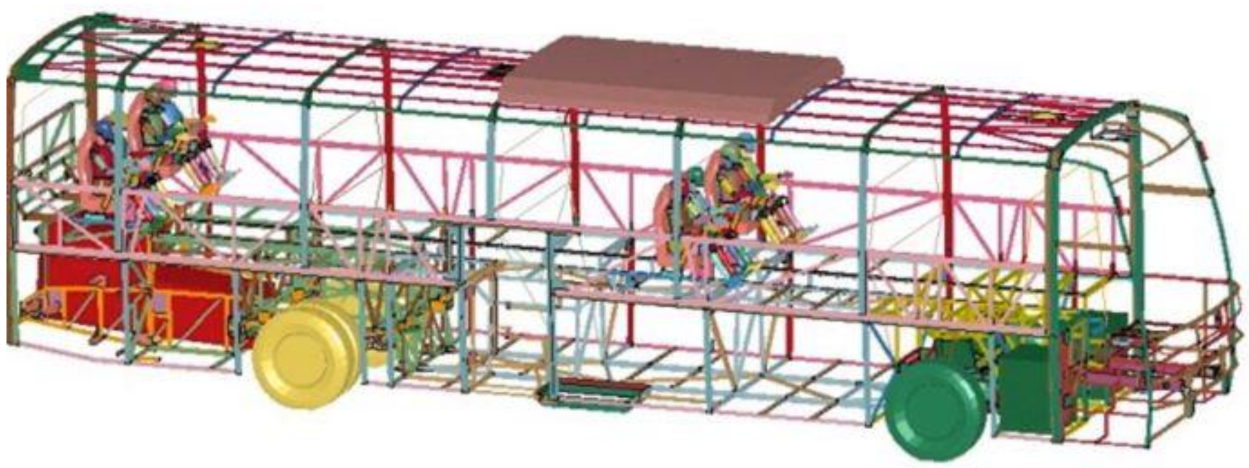

Figure 3. Structural parts of the bus [3].

Based on many years of practice and numerous scientific researches, it has been determined that the highest risk of life-threatening bodily injuries, passengers gain in an accident when a bus overturns, usually in 4 (four) cases:

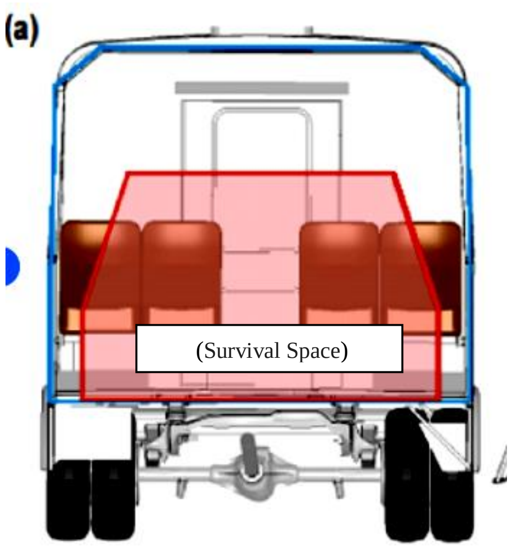

Figure 4. Survival space in the passenger cabin [4]. -

- The first case is when there are large structural deformations whereby the survival space of the passengers in the bus is reduced (narrowed) and the structural parts of the bus come into direct physical contact with the body of the passengers,

- The second case is uncontrolled movement of the passengers in the passenger compartment during the overturning of the bus and they make physical contact with parts of the bodies or with parts of the interior in the passenger compartment of the bus,

- The third case is when there is contact between the bodies of the passengers in the passenger compartment with parts and objects from the external environment, where they acquire scratches, cuts, bruises, fractures or amputation of a compressed part of the body.

- The fourth case is when the body of the passenger is completely thrown out of the passenger space outside the bus through a window or other opening and will be pinched, i.e. killed by the bus from which it was thrown.

The Regulation ECE R66 introduces the strictest criteria in terms of improvement, i.e. improvement of the structure of the buses through the use of better quality materials (aluminum, etc.) which meet the following characteristics [5]:

- Greater strength and durability
- Are lighter in weight
- They have a great ability to absorb kinetic energy

Regulation ECE R66 obliges bus manufacturers to carry out upgrades and structural modifications to strengthen and protect the passenger's survival space when the bus overturns. Among other things, it is essential that this regulation stipulates that when the bus overturns, its structural parts must retain the volume space for passenger survival, i.e. to prevent its reduction or penetration of structural parts of the bus and contact with the bodies of passengers, and at the same time be able to absorb the action of kinetic energy with a strength of at least 30kJ.

When overturning the bus, its structural parts are most loaded and deformed in the most protruding upper rounded part, whose deformation should be max up to 250mm, while in the lower part it should be max up to 150mm. The residual part (passenger survival space) calculated from the lowest part of the floor under the feet of the passengers to the roof upwards should be kept at a height of h = 1250mm as seen in Fig.5:

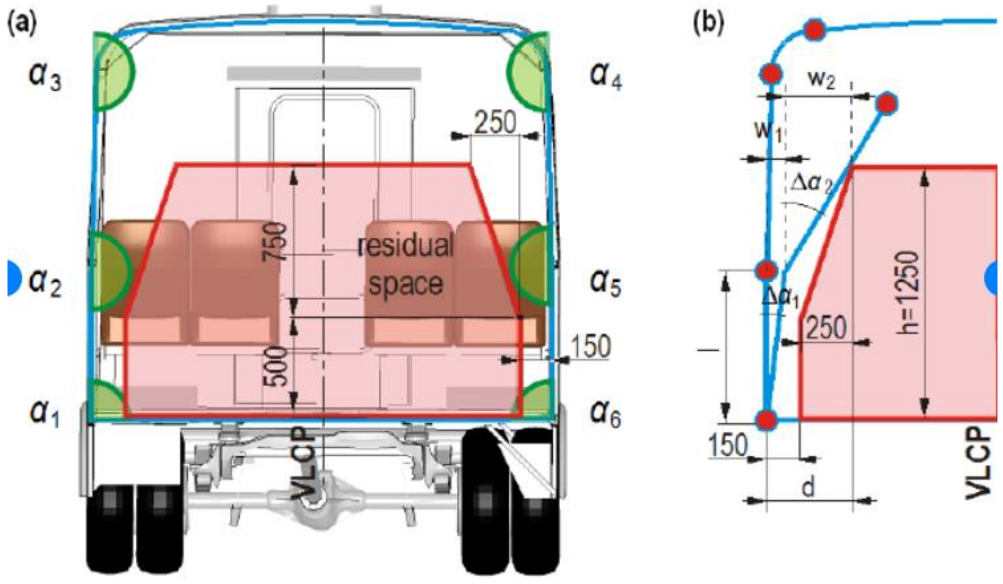

Figure 5. Survival space in the passenger cabin [4].

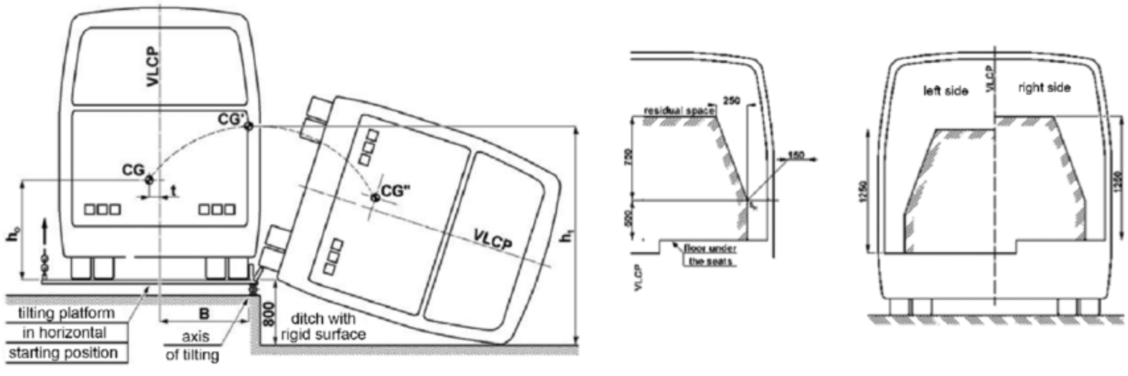

Figure 6. Survival space in the passenger cabin after a rollover [3].

During an uncontrolled overturning of a passenger bus, the severity of the passengers' injuries, apart from the quality of the structural modification of the buses in accordance with the ECE R66 regulation, to a considerable extent depends on other factors such as: the speed of the bus before being brought into unbalanced motion, by the weather conditions, the properties and the configuration of the terrain on which the bus overturns, by the primary contact of the structural parts of the bus with the environment and the terrain, by the location of the passengers accommodated in the travel space, by the passive safety elements built-in bus and so on.

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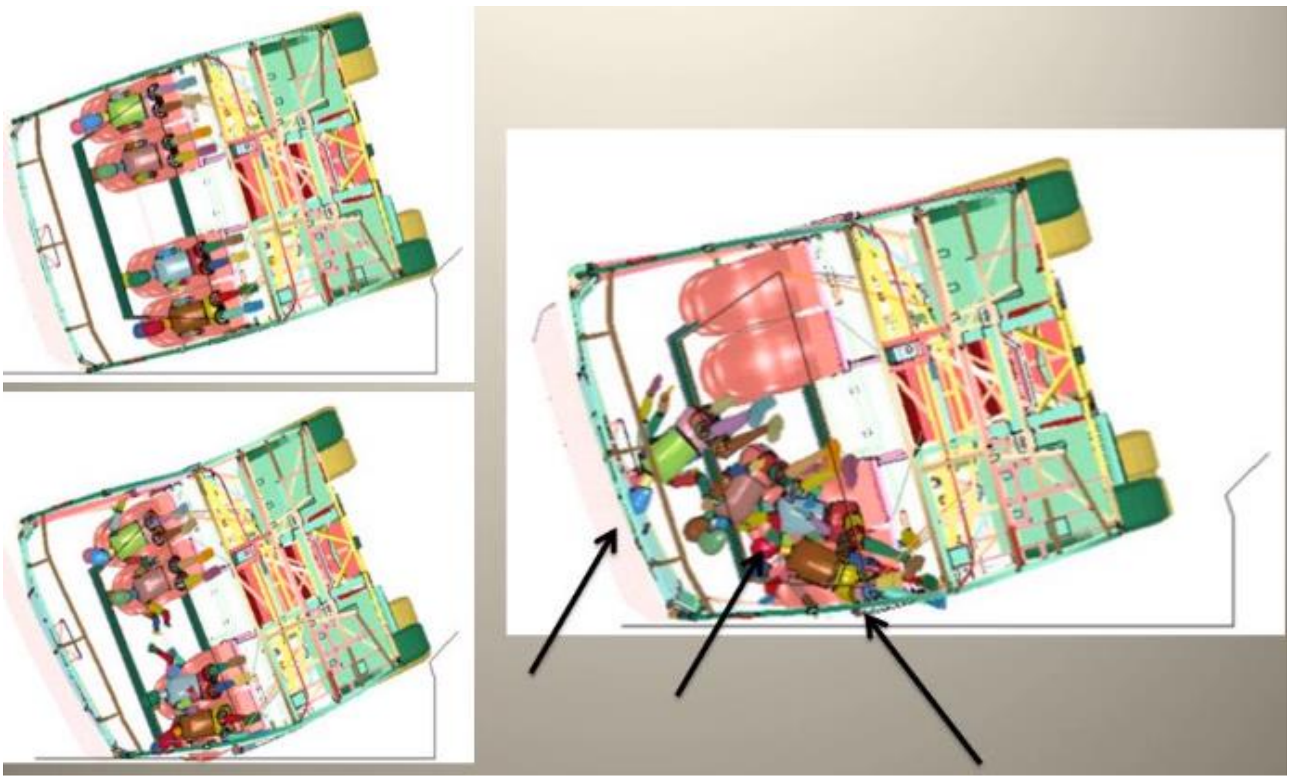

Figure 7. Uncontrolled movement of the bodies of unattached passengers when the bus overturns [4].-

From Figs. 8 and 9 it is evident that in addition to strengthening the structural parts of the bus and preserving the residual space of the passengers, a very big role in the function of safety and protection of passengers when overturning the bus have the seat belts built into three points of the bus seats in accordance with ECE R80.

Unfortunately, a very small number of the fleet of buses operating in our country meet the highest criteria prescribed by ECE R80, i.e. the buses are not equipped with 3-point seat belts for passengers, hence the severity and consequences of injuries to passengers end up as fatal outcomes or severe physical disability.

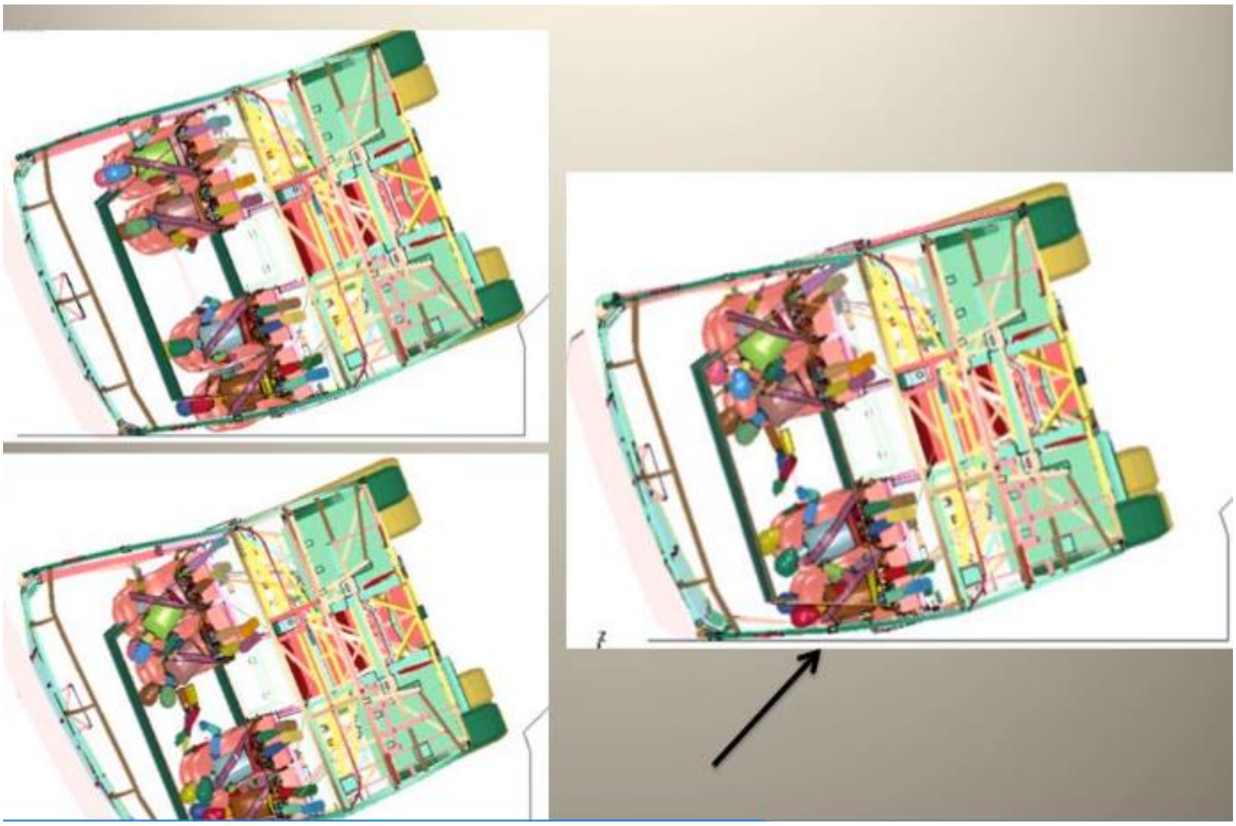

Figure 8. Holding the bodies of the bound passengers when the bus overturns [4].-

Figure 9. Example of a broken rolled over passenger bus [true case]

Figure 9 shows the condition of a passenger bus after it overturns along the road. As it can be seen in the photos, the mechanical damage to the body of the bus corresponds to the damage and deformation described above in the schematic descriptions of deformation the body of the bus and the preservation of the space provided for the "survival" of the passengers. In this case, before overturning, there is a fall of the bus from a greater height, which resulted in such an intensity of damage and such a degree of deformation of its body.
In this case, the accident resulted in a large number of dead and severely injured passengers. In addition to the fall, overturning and huge deformations of the body, the reason for such catastrophic consequences for

the life and health of passengers is of course the lack of seat belts for passengers in the passenger seats, which would keep the passengers in their seats.

4 Conclusion

Passive safety systems for vehicles in general, and of course those installed in vehicles for mass passenger transport, are extremely important for reducing the consequences of traffic accidents. The greater the number of built-in systems and elements in charge of passive safety, the greater the chances of reducing the consequences of the accident, especially in terms of health and life of the driver and passengers in the vehicle involved in the accident. The various passive safety systems and devices should complement each other to reduce the risk of injury to the driver and passengers. Such was the case with the construction of the body in order to provide sufficient space for the survival of passengers in the overturning of the passenger bus, in combination with seat belts for passengers.

It is of great importance that the passenger buses available to our transport companies reform their activity - national and international passenger transport needs to follow the world trends in every respect according to the latest technologies for the production of vehicles, both in terms of systems and devices for active safety, as well as in the segment of passive security.

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