

# Compartmentalization and Seat Belts

## The Inconvenient Truths

by Larry Plachno



Compartmentalization and seat belts are major factors in bus safety but are often misunderstood. Both compartmentalization and seat belts can improve passenger safety if utilized properly. Compartmentalization and seat belts can be used independently or together. MCI.

Compartmentalization and seat belts are a very complex area and one of the major concerns of the bus industry. However, a lack of information as well as misinformation makes it difficult to understand and evaluate alternatives. Our thanks to Ned Einstein and Dr. Anil V. Khadilkar for sharing their expertise and

pointing us in the right direction to put together this article.

Since most motorcoach seats are already so close to true compartmentalization, I, as well as others, have questioned why those involved have refrained from making the effort to go the remaining distance. One of

my reasons in writing this article is to prompt one or more coach or seat manufacturers to take the remaining steps.

Another reason for writing this article is to cover the pros and cons of compartmentalization so that seat manufacturers, coach manufacturers and bus owners can make

informed decisions on compartmentalization and seat belts.

You have my permission to make copies of this article to send to seat manufacturers, coach manufacturers and your politicians. In fact, I will try to see that a PDF version gets placed on the [www.busmag.com](http://www.busmag.com) Web site to make sharing this information easier.

### Misinformation

Here are some of the typical items of misinformation that confuse people when dealing with compartmentalization and seat belts.

- Buses are not airplanes and not automobiles. Due to different operating characteristics, what works on an automobile or airplane may not be best for a bus. This mistake is a typical failure of politicians who shoot from the hip instead of paying attention to the research and the experts who conducted it.

- True compartmentalization is more than just a row of forward-facing, padded seats. The current design of intercity coaches superficially resembles compartmentalization, and further, provides an excellent starting point for developing it. This starting point is the primary reason why intercity coaches have such a high safety record.

- In common with many technologies, seat belts involve trade-offs. As a consequence, there are some negative aspects to seat belts, and in many scenarios (particularly with child passengers with underdeveloped internal organs) seat belts can be worse than no seat belts. Compared to compartmentalization, one big negative with seat belts is the possibility that they may not be used.

- Push-out escape windows and passenger windows that are not laminated safety glass are highly questionable. The original reason for the mandate for push-out windows has long since passed. Due to the large windows on motorcoaches, some form of technology to minimize ejection is an important and constant concern, a concern that will not go away, and one often drawn to the public's attention following a catastrophic motorcoach accident.

Compartmentalization and seat belts should have two main goals. 1. Keeping passengers in their seat while minimizing the effects of an accident. 2. They should provide protection from rebounding and oblique impact collisions. Bear in mind that since 70 percent of vehicle accidents are frontal collisions, compartmentalization and seat belts are primarily geared to minimize the impact on passengers of this type of accident.

### Mass Matters

A frequently overlooked fact is that buses are usually heavier than other vehicles on the road except the heavier trucks. Motorcoaches typically have approximately 10



One major advantage of riding in a bus is that it far outweighs most other vehicles on the highway. Hence, in any altercation between a bus and an automobile, the automobile and its passengers usually come out second. That is why Volvo is offering their Front Underrun Protection System to reduce the damage to automobiles in front impact collisions. VOLVO.



Push-out passenger windows are typically American. European buses have solid windows with little hammers to break the glass in the event of an emergency. Here is a European Volvo 9700 with three-point seat belts and European solid passenger windows. VOLVO.

times the mass of an automobile. Further, crash forces reflect the velocity of the vehicle or vehicles involved. Hence, a 40,000-pound bus will pretty much wipe out a 4,000-pound car. These differences in mass account for the fact that buses have safety records dramatically better than those of automobiles. Most bus accidents are very survivable. More often than not, fatalities occur when passengers are ejected.

Likewise, buses are considerably different from airplanes. Commercial aircraft speeds are often as much as 10 times higher than typical bus speeds. If you hit the ground

at a high rate of speed, there is little in the way of safety features that will help. Accidents at typical bus speeds are almost always survivable.

### Push-Out Windows and Laminated Safety Glass

Let me briefly digress from compartmentalization and seat belts to talk about the related topic of push-out windows and laminated safety glass. This is a major concern because in serious accidents and rollovers, the passengers thrown out of the coach are more likely to suffer injury or death.

Push-out windows are typically American. The Europeans use solid windows and provide a hammer to break the glass in case of an emergency. I am not going to say that push-out windows are not useful. If you prop them up with a two by four, you can get all kinds of big things (including seats) into and out of a bus without having to struggle through the front door or having to remove the windshield glass. However, push-out windows are undoubtedly a case of questionable legislation.

Legislation requiring push-out windows followed a disastrous accident on a Texas highway many years ago when two gasoline-powered buses hit head on and their passengers were trapped in the resulting inferno. Today's modern motorcoaches are diesel powered and hence are no longer subject to explosions and fires caused by fuel. The one recent exception to this was the disaster in Texas during the Hurricane Rita evacuation. This situation was different because of the presence of oxygen and the use of a non-lift equipped bus with non-ambulatory passengers.

How useful are push-out windows today is a subject for debate. More than one person has said that it would require a strong athlete to simultaneously push out the windows and then drop to the ground. Moreover, many if not most passengers are not even aware of how the windows work because most bus companies do not have a pre-departure safety lecture like they do on the airlines.

Another school of thought suggests that even if the push-out windows remain latched, passengers are still being ejected from the coach through those large passenger windows in the event of a major accident or rollover. There is no requirement for laminated safety glass on passenger windows and hence passengers could be ejected from the coach through windows where the glass has been shattered.

With the exception of this one recent incident in Texas involving passengers with impaired mobility and oxygen cylinders, modern coaches do not explode or catch fire quickly. Passengers typically get out of the front door before there are any major problems. On the other hand, more bus passengers have been injured or killed by being thrown out of windows in an accident than have been saved by pushing out the windows to escape a bus fire.

### Compartmentalization v. Seat Belts

Before getting into a discussion of compartmentalization and seat belts, it would be wise to compare the two containment systems. Compartmentalization works even if the passenger does nothing. With seat belts, the passenger must properly connect the seat belt for it to be useful.

However, there is another consideration in our litigious society. In the event of an acci-



Seat belts are becoming increasingly popular on American buses. This 2006 photo shows a Sprinter with built-in three-point seat belts. Many large coaches are now also offering seat belts. NBT.

dent, any problem or failure of compartmentalization will be blamed on the operator or the coach or seat manufacturer. On the other hand, it would be difficult to direct blame at anyone else if a passenger were injured because they failed to click their seat belt.

From the standpoint of cost, there are other things to consider. It might be noted that there is no guarantee that building a motorcoach with true compartmentalized seats will be less expensive than installing seat belts. On the other hand, seat belts also

increase costs. If you anchor seat belts to the seats themselves, you increase the potential load on the seats and must develop an anchoring system capable of handling these increased forces. The ideal situation would be to anchor the seat belts to the floor, but this increases cost and makes it more difficult to move or respac seats.

### Compartmentalization

Let us start with a simple statement. Requirements and specifications have been developed for compartmentalization in

Modern motorcoaches are already very close to true compartmentalization, which is a major reason why motorcoaches have such a high safety record. However, the research and development of criteria for motorcoach compartmentalization has never been done. Similar research and the development of criteria has already been done for school buses. MCI.



school bus seating but not in motorcoach seating.

For decades, NHTSA has favored compartmentalization over seat belts in school buses. There are numerous reasons for this including the possibility that seat belts can be misused, they can be unused, and they present problems where you try to get two or three students in one seat on different trips. NHSTA has also been concerned about children being injured by seat belts, particularly two-point seat belts, because of their underdeveloped internal organs.

A recent NHTSA four-year study (2000 to 2004) re-confirmed that lap belts are dangerous and NHSTA still refused to endorse three-point belts although it acknowledged that they present fewer problems and have more value. An interesting side note in regard to school bus safety is that injuries to children in the "danger zone" externally adjacent to the bus are substantially more of a concern than accident injuries to children inside the bus.

Dr. Anil V. Khadilkar and others were involved in a major NHSTA project in the mid-1970s to improve school bus transportation safety. One aspect of the research involved looking for ways to improve the school bus structure, including any application of aircraft techniques. A second aspect was developing a true compartmentalization. The research was based on the fact that most school bus accidents occur at low speed and that 70 percent of vehicle accidents involve a frontal impact.

Structural research was given up because of difficulties. Among other things, Crown was the only manufacturer offering an integral school coach then, the other school buses were body-on-chassis. Research moved ahead and was successful regarding compartmentalization. The necessary seat back height was clearly defined, proper seat spacing was determined, and requirements for seat spacing and anchoring were developed. Equally important, criteria were developed for proper padding on the seat backs in the knee, chest and head area as well as seats deforming or deflecting during an accident. This information was used to develop FMVSS 222 and a few related regulations.

The equivalent compartmentalization research and the development of similar criteria for motorcoaches has never been done. Why? Granted it would take some time and money, but probably not a great deal since the motorcoach industry is already very close to what is needed. On the negative side, the research for motorcoaches would have to take into consideration higher operating speeds and dealing with reclining seats. Items on the back of seats, such as folding tray tables, might be a serious impediment to proper compartmentalization.



An additional concern for both seats and seat belts is sufficient anchoring. Anchoring seat belts to the floor limits the ability to respac seats if needed. When seat belts are incorporated into the seats, the seats will require additional anchoring because of the added stress. Shown here is the interior of a European Jonckheere bus. VDL.

On the positive side, motorcoaches have arm rests and overhead parcel racks which help with compartmentalization. In addition, the existing highly padded seats would lend themselves well to the proper padding where knees, chest and head would come into contact with the seat ahead. Dr. Anil V. Khadilkar, who helped with this same research for NHTSA for school buses, has offered to manage such a project if anyone is interested.

#### Two-Point Seat Belts

Two-point seat belts (lap belts) are frowned upon by the experts. The most obvious problem is that when the passenger's waist is restrained by a lap belt, it creates a fulcrum that accelerates their heads into the seat backs in front. While a simple accident can be easily survivable with compartmentalization and no seat belts, that same accident can become lethal with two-point seat belts. Note that automobiles have now gone to three-point seat belts for this reason.

Europeans are more likely to take public transportation and more likely to use seat belts. Shown here is a Volvo 8700 bus with three-point seat belts. Three-point belts are now available on some American coaches. VOLVO.



Another negative feature is that two-point seat belts may defeat and work against compartmentalization. In true compartmentalization, seat backs are padded to protect the knees and head, and also to protect the upper torso when a passenger is thrown forward in an accident. Two-point belts constrain the passenger's waist and hence can cause their head to strike the seat back at the wrong location for compartmentalization to be effective.

There are other reasons to look unfavorably on two-point seat belts. Since their internal organs are not fully developed, any seat belt, and particularly lap belts, can cause serious internal injuries in children. This is one reason why several states have enacted laws to keep children in children's car seats and restraint devices for several years until they reach a certain height or age. There is also a concern that seat belts could become the weapon of choice in a school bus fight. These problems are almost as bad with three-point belts but because three-point belts avoid the fulcrum problem, they are considered better.

### Three-Point Seat Belts

Three-point seat belts (lap belts with a shoulder belt) have both positive and negative features when compared with two-point belts. The major positive feature is that three-point belts offer much better restraint than two-point belts. With the three-point belts a passenger is more likely to be restrained from hitting his head on the seat in front. Negatives include the fact that there is a far greater chance of neck injuries from oblique and side accidents when using three-point belts.

Seat belts can also pose a seating capacity problem for certain school buses. Some are set up with long seats that will accommodate three smaller children but only two high school students. This presents a problem in setting up seat belts, although we were told at least one seat manufacturer has come up with a clever solution.

Another point is that seat belts can provide too much restraint. In the event of a rollover accident, the pressure of the passenger's weight on the seat belt may make it difficult, if not impossible to release the mechanism. Hence, passengers can easily be trapped while the fire approaches, the fumes increase or the water rises.

Of course, the bottom line with all seat belts is that they are useless if not used. It is a known fact that many Americans are still fighting the use of seat belts.

### Conclusion

If you have read this far, here are a few things for you to consider. The motorcoach industry is remarkably close to true compartmentalization. It would take very little effort to make that sprint to the finish line. Compartmentalization works even if



The BCI Falcon differs from most buses sold in America in having seats anchored to the chassis structure. Seat belts are incorporated into the seats but the seats are not only mounted to the floor but to a U-shaped frame member under the floor. While this makes moving seats difficult, it does provide excellent seat anchoring in the event of an accident. NBT.

passengers do not click their seat belts. I might also point out that the use of compartmentalization and seat belts are not mutually exclusive. A very interesting option would be for a motorcoach or seat

manufacturer to make the investment to develop full compartmentalization and then add three-point seat belts. The resulting coach would get extremely high marks in passenger safety. □

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