Submission and Appendix of BUSCO to the National Transportation Safety Board

Mexican Hat, UT
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Alternative Crash Theory – Mexican Hat, UT.
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Introduction

I would like to introduce an alternative crash theory to the motorcoach crash near Mexican Hat, UT which occurred on January 6, 2008. The DriveCam recording of the accident looking out of the front of the motorcoach, as I recall, shows an inexplicable shift of the front end of the motorcoach to the right when the motorcoach enters the curve. The footage shows the driver reacting instantaneously to the shift, which I will later describe as an under steer condition.

The reports that I have read have statements such as, "After entering the curve, the motorcoach departed the roadway…" None of these reports have any explanation of **why** the motorcoach departed the roadway.

My hopes are that this report will show that perhaps there were more factors to this accident that may have gone unexplored.

UMA Safety Management Seminar – December 4, 2008

During the UMA Safety Management Seminar, Roger Saul Ph.D., from the National Highway Traffic Safety Administration (NHTSA) delivered a presentation on the bus crash testing that was conducted in 2008.

After the presentation, I had the opportunity to ask Dr. Saul if he was aware of any sort of manufacturer handling, maneuvering, and stability testing that is performed on motorcoaches. He was not aware of any.

We already know that crash testing is not performed by the manufacturers. I hope that in addition to heightened awareness for the need of crash testing for such things as rollover's and roof integrity, that my report will spur new interest in the handling characteristics of motorcoaches.

Considering potential future litigation regarding the Mexican Hat, UT accident, I have not made contact with any manufacturers (such as MCI, Setra, Prevost, Van Hool) to see if any sort of handling and maneuvering testing is done on their products. I believe this is something that needs to be researched.

Basic Weight Distribution (Exhibit A)

The engine and transmission of a motorcoach is located in the rear of the vehicle behind the rear axles. In addition to the engine and transmission, the lavatory (with liquid holding tanks) is located behind the rear axles. One must also consider the weight of the rear axle assemblies including suspension, tires and wheels.

Immediately in front, or in the near vicinity, of the rear axles are the fuel tanks. Also, as a practice on trips that may include driving in snow, drivers are known to load as much luggage as possible to the rearmost portion of the luggage bays, and as high as possible. They tier it down as they move forward in the luggage bay. This is done in an attempt to keep as much weight to the rear as possible for traction.

I have not seen any documentation from any of the investigating agencies where representatives of our company (i.e. the driver) were asked about the placement of luggage or how full of fuel the tanks may have been at the time of the accident. I also have not seen that the driver was asked about the tag axle.

The tag axle is the rearmost axle and is adjustable (up and down only). The tag axle can have pressure released from it so that all the rear weight of the vehicle goes onto the drive axle. This is another tool available to the driver for traction. Some motorcoaches are equipped with an alarm to indicate to the driver that the tag axle is not fully engaged when they begin to travel down the roadway. If the tag axle had not been engaged, this would have exacerbated my theories on weight distribution, handling, maneuvering, and stability. At the moment, this is not believed to have been an issue. For the purposes of this report, I felt it needed to at least be mentioned and/or explored. The tag axle on the accident motorcoach was a non-steering tag axle. This means all six rear tires are continuously pushing the motorcoach straight forward. Manufacturers such as Setra have a steering mechanism built into their tag axles.

With all this weight towards the rear, especially the engine, transmission, lavatory and tanks, the rear axles would serve as the fulcrum of the motorcoach. Weight placed behind the fulcrum would unload the front axle.

Tag axle pressure and anything loaded ahead of the rear axles (fulcrum) would add weight to the front axle. To what amount and how steering, handling, maneuvering, and stability are affected is likely unknown.

In weight distribution, there are only three significant factors that constantly change; passengers, fuel load, and luggage. With this being taken into consideration, I think it would be possible for bus manufacturers to perform handling, maneuvering and vehicle stability testing incorporating these potential changes to fabricate the best handling bus on the highway. Centers of gravity could be tested to ensure that these three changes in weight distribution are incorporated into the handling characteristics of the motorcoach to ensure there is not significant change between a loaded or unloaded motorcoach.

Weight Distribution Affect on Handling

Employees have reported to me that on a slick surface, i.e. a wet or snow covered parking lot, the front tires of the motorcoach, particularly the MCI, can be steered completely to the right or left, and when they begin to accelerate, the front of the motorcoach will plow straight ahead rather than turning. This under steer or push condition is likely caused by a large portion of weight being near or behind the rear axles.

The motorcoach also has six tires on the rear two axles; four on the front of the two axles, and two tires on the rear (tag). On an MCI motorcoach, the rear axles are fixed and do not steer (the tag will only lift up and down). This results in six tires, heavily weighted and firmly planted, pushing two steer tires on a much lighter axle straight ahead at all times. In my opinion the weight configuration combined with the steering configuration lends itself to a vehicle with a significant under steer condition built in.

Other types of motorcoaches offer tag axles with steering capabilities, as well as independent front suspension. My understanding is that the MCI has a straight front axle. It is not known what sort of affect these items may have had on this particular accident. That is why there must not only be a call for more motorcoach crash testing, but testing of maneuvering, handling, and stability as well.

Utah Route 163

Reports have indicated that there was a significant downgrade approaching the left hand curve and the posted speed limit was 65 mph, with only a sign indicating that a curve was ahead. Reports also indicate that there was some banking built into the curve, and the surface at the time of the accident was dry.

Throughout the investigation, the actual speed of the motorcoach has not been determined. One report indicates that speed was not believed to be a factor. Another report is inconclusive.

If the vehicle was traveling at the posted speed limit and entered this curve with banking, is it possible that the vehicle experienced a severe under steer entering the curve? This would explain the sudden right hand drift in the DriveCam footage. The driver reacted instantly, but it appears that the under steer condition is severe enough that by the time the driver gains any kind of control, he has perhaps dropped the right front of the vehicle off of the paved surface.

One report indicates that this particular section of roadway has a 60 mph design speed. There have been reports that the State of Utah has posted a lower speed limit at this particular curve since the accident. The original posted speed limit (65 mph) was above its original design speed of 60 mph.

Immediately following this accident, media reports featured quotes from local residents that large commercial vehicles should not be on this road. I would like to surmise that this road should have been posted prohibiting larger commercial vehicle traffic, or the curve should have been specifically tested with larger commercial vehicles (if it was not) for possible lower speed limits and warnings.

Center of Gravity (c.g.) Hypothesis

The longitudinal c.g. of the motorcoach should be closer to the rear than it would be the front. The height of a motorcoach should cause the vertical c.g. to be considerably higher than that of an automobile. The lateral c.g. should be somewhat close to center as the motorcoach appears to be well balanced from side to side. If the State of Utah tested the curve with only an automobile, the test may have been insufficient for larger commercial vehicles at the same speed with a much higher vertical c.g.

Considering that the longitudinal c.g. is likely closer to the rear, and that there is a "weight" on the extreme rear of the vehicle being the engine, when the driver reacted to the right drift of the vehicle at the front by steering left, the weight of the rear began to move or swing to the right, throwing the weight of the vehicle excessively off of its c.g.. It appears on the DriveCam footage that the driver was beginning to gain control of the front of the vehicle, and then the momentum of the "pendulum weight" (engine) at the rear pulled it from the roadway.

I think computer animation, which I'll detail later, would possible prove this theory.

Tire Slip Angle and Under Steer

If the motorcoach involved did have a severe under steer condition, there is also a chance that when the driver began to correct the right hand drift (aka push, plow, under steer), that the front tires ability to grip the road surface was exceeded. Once a tire is turned and begins to lose traction and skid across the pavement, its slip angle has been exceeded.

Computer Animation

If a motorcoach of the same year, make, & model of the accident motorcoach was mocked up and weighed, I believe it could be placed into computer animation and we would have a better understanding of why the accident motorcoach left the roadway.

Weights of each axle, and each tire/wheel could be taken for the accuracy of the animation along with accurate dimensions of the motorcoach.

Computer animation could possibly pinpoint the vehicles c.g. as depicted in Exhibit E. The height of the bus and the affect of having a high c.g. or top weight (and its lateral affect) could be simulated. The road surface could be simulated. All the simulations, including the speed of the bus could be re-enacted.

There is the possibility that the computer animation could show that the motorcoach was capable of leaving the roadway at 65 miles per hour, or possible even less, due to the overall design, that design being the weight distribution and centers of gravity. The pendulum effect of the engine could also be recreated.

Step By Step Sequence of Events

1) Motorcoach begins to enter curve.
2) Front tires lose grip with road surface due to under steer.
3) Driver reacts instantly as if something doesn't "feel right". The driver turns the steering wheel to the left.
4) The under steer condition combined with left steering input by the driver results in tire slip angles being exceeded. The driver turned and the vehicle went straight ahead.
5) At the top (right) side of the roadway curve the front tires and front end of the motorcoach begin to get some traction, but the rear of the vehicle, particularly the weight of the engine have lost it's forward inertia and has been thrown to the right causing the pendulum effect.
6) The right front tire may have left the road surface. If it did, the front axle may have bottomed out. This may have caused a very abrupt decrease in vehicle speed and actually exacerbated the pendulum effect of the rear.

7) The height of the vehicle (and high vertical c.g.) results in the top of the motorcoach being thrown to the right. The height, high vertical c.g., and the pendulum effect are all happening simultaneously as a result of the initial driver correction attempt (steering left).
8) The rear of the motorcoach continues its right or counterclockwise motion due to the weight of the rear, and the rear begins to pull the motorcoach down the embankment.
9) As the motorcoach slides down the embankment sideways, it rolls a complete 360° and lands upon its wheels.

Conclusion

This alternative theory has been on my mind for many months now. While explaining the theory to many others in the motorcoach industry and government agencies, I was encouraged to put it into writing and to submit it.

The driving force behind why I came up with this theory has always been, "why did the motorcoach leave the roadway?" I do not believe this question has yet been answered and I think my theory provides possible answers.

At times when I have had access to the DriveCam recording, I have watched it countless times. I have watched the vehicle positioning on the roadway and its drift to the right very closely and at many different speeds. I've watched the driver's reaction to the drift and played it forward and backward at different speeds countless times. His reaction to the drift is nearly instantaneous, as if he felt the drift right away and tried to correct it.

I don't know whether anyone will ever be able to pinpoint the exact speed. However, if computer animation recreating the accident shows that there is a probability that the vehicle may have departed the roadway at a speed of 65 mph, or even lower, incorporating the theories I have shared; many unanswered questions could be resolved.

I have not seen any documentation addressing any of the theories I have presented. I think it would be a huge mistake not to explore these theories any further. From this point forward I am somewhat limited in testing my theories. I am hoping that someone finds these theories legitimate and can assist me in moving forward.

If any of my theories are tested and proven correct, my hopes are that the information will help to improve highway passenger transportation, make the vehicles safer, and prevent future accidents.

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Appendix 1

MCI Service Bulletin No. 3005 (12/22/2008). Please see the next page. This service bulletin states that beginning with unit 64918, Electronic Stability Control (ESC) is now equipped on J4500 series coaches. The ESC is interestingly combined with Roll Stability Control (RSC). The service bulletin goes on to describe (please read) the ESC and RSC detecting and potentially preventing such things as; skids, rollover protection, directional stability, spinout, and driftout.

During a conversation with a veteran driver, he described how the MCI J4500 seems to level out while going through a curve. He thought that this leveling affect was due to some sort of suspension mechanism that helps level the bus for passenger comfort. If there is any truth to this, that means this particular bus may have attempted to level and therefore shifted even more weight towards the right. I discussed this with our Director of Maintenance, Gene Wordekemper. He said there are sensors for air adjustment to the axles, much like those that are in tractor-trailer units to distribute and/or equalize axle weight on air ride style suspension.

During the conversation with Gene Wordekemper I was advised that there have been times that during a tight curve it has been witnessed where a front tire lifted off of the road surface. This would be a tight curve situation where the motorcoach is traveling fast enough to maintain control, but at a speed that technically is too fast for the curve.

Service Bulletin No. 3005

MODEL	TYPE	SECTION/GROUP	DATE
J4500 Series Coaches	Service Information	4–Air System and Brakes	Dec. 22, 2008

SUBJECT	ELECTRONIC STABILITY CONTROL (ESC)
CONDITIONS	Service Information Only

Description:

Effective with unit number 64918, J4500 series coaches are now equipped with a MeritorWABCO stability control system that features Electronic Stability Control (ESC) combined with Roll Stability Control (RSC). ESC is a computerized technology that improves the safety of a vehicle's handling by detecting and potentially preventing skids by automatically applying brakes to help steer the vehicle where the driver wants to go.

RSC is based on the Anti–lock Braking System (ABS) and is designed to help the operator manage road conditions that can lead to vehicle rollovers. ESC combines RSC rollover protection with directional stability to reduce the likelihood of spinout and drift out.

ESC is automatic in that these systems become active when the system Electronic Control Unit (ECU) senses conditions that could produce imminent roll or directional instabilities. Rapid lane changes or cornering at excessive speed on dry or slippery surfaces can create the potential for spinout or driftout, often before the operator is aware. The ESC system uses a lateral accelerometer, a steer angle sensor in the steering column and a yaw rate sensor to enhance the operator's control in these conditions.

The lateral accelerometer input provides basic RSC functionality and reacts by applying brakes simultaneously to all wheels to reduce speed and limit cornering acceleration and forces. The steer and yaw sensors assist the lateral accelerometer to enhance RSC functionality by modulating the simultaneous brake applications to all wheels. The steer, yaw, and lateral accelerometer sensors combine to provide additional directional control by selectively applying brakes to the steer axle wheels individually, to bring the coach back to its intended direction, which reduces the steering effort typically required to stabilize the coach in such events.

During a lane change maneuver from a dry lane to a slippery lane, the coach first goes into a roll control event (RSC) where all the brakes are applied to slow the vehicle down in an effort to prevent a potential rollover. The coach then goes into a directional control event in an effort to straighten out and prevent it from leaving the road.

NOTICE

The stability control system is designed to assist the operator, not to replace the operator.

The operator will notice a difference in the coach when the ESC system becomes active, but should continue to drive as normal and provide any additional needed corrections. In an ESC event, the operator may first sense a decrease in engine power as the system ECU overrides the accelerator pedal, and may then sense additional deceleration from an engine brake application and service brake applications on the steer axle brakes or all axle brakes, depending on whether the conditions suggest the possibility of a directional control or a rollover event.

CAUTION

Electronic Stability Control, or any other coach control system, is not a reason to take unnecessary risks.

Electronic Stability Control helps reduce coach instabilities when cornering or when sudden changes in direction occur, however, it cannot prevent all instabilities from occurring.

When operating your coach, always use safe driving techniques. The operator is always the most important player in safe coach operation.

Remember, no safety system can prevent all accidents. There is no replacement for an alert, unimpaired driver following safe driving procedures.

The ESC and Automatic Traction Control (ATC) functions share the same tell–tale lamp in the RH tell–tale cluster (refer to Figure 1). At system start–up, tell–tales illuminate briefly for self–test. If the coach is equipped with ESC, the ESC / ATC tell–tale will remain illuminated approximately one second after the ABS tell–tale lamp extinguishes.

Figure 1. RH tell–tale cluster.

During a traction control or stability control event, with the Mud/Snow switch in the OFF position, the ESC / ATC tell–tale will illuminate solid. The tell–tale will extinguish when normal driving conditions are resumed.

During a traction control event, with the Mud/Snow switch in the ON position, the ESC / ATC tell–tale will blink continuously. The tell–tale will extinguish when normal driving conditions are resumed.

If the ESC / ATC tell–tale remains illuminated solid during normal driving conditions, there is an existing fault in the ESC system. If the ABS tell–tale remains illuminated solid during normal driving conditions, there is an existing fault in the ABS or ATC system. If there is a fault, perform diagnostics using the latest version of TOOLBOX™ Software to identify fault and have coach serviced as soon as possible.

After servicing, the ABS tell–tale illuminates at ignition and extinguishes when the coach is driven above 4 mph.

NOTICE

Owners of MCI coaches between the range of, and including, 64918 and 65158 are instructed to apply the supplied Electronic Stability Control decal to the instrument panel to notify operator that coach is so equipped.

The number of decals in this envelope, relates to the number of affected coaches in your fleet.

Parts

Qty.	New P/N	Description
1	03-15-7171	Decal, This Coach is Equipped with ESC

Service Information:

1. New part will be available for service replacement.

Service Procedure:

General notes

Use Safe Shop Practices At All Times.

1. Using a clean rag and an isopropyl alcohol / water mixture, clean the surface where the decal is to be applied (Figure 2).

NOTICE

Allow enough time for the isopropyl alcohol / water mixture to flash off.

2. Apply the decal, p/n 03-15-7171, on the designated area.

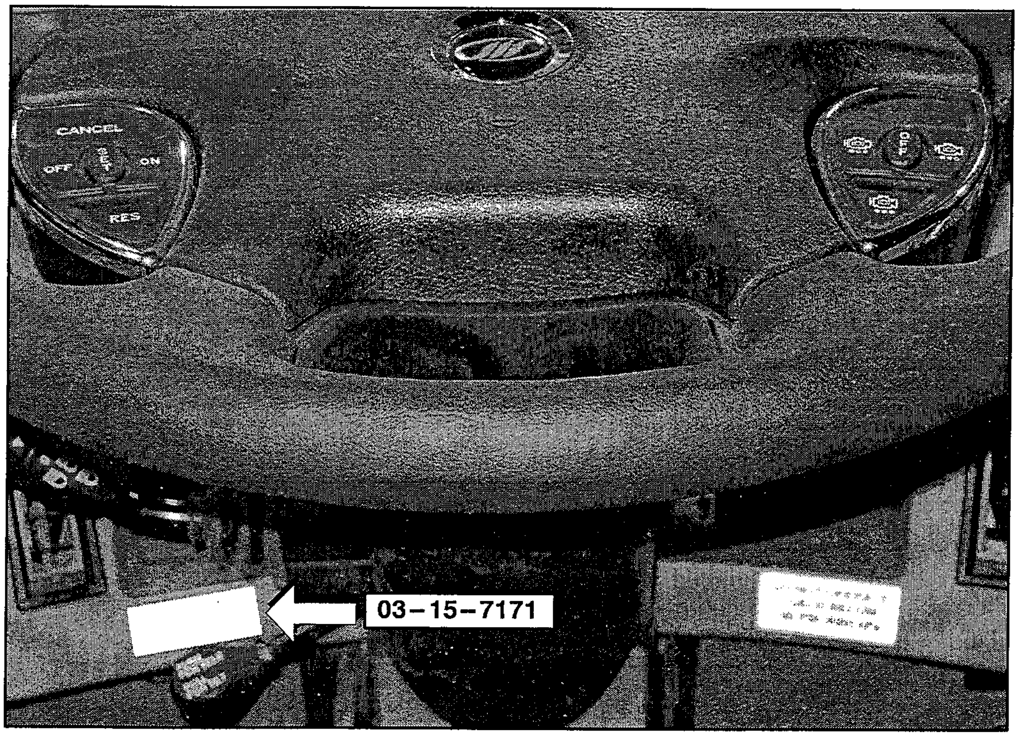

Figure 2. ESC equipped coach decal location.

Procedure complete.