

Mariusz Ziejewski, Ph.D., Inż.

Professor

Department of Mechanical Engineering

Director of Impact Biomechanics Laboratory, College of Engineering

Director of Automotive Systems Laboratory, College of Engineering

North Dakota State University

and

Clinical Faculty

Adjunct Associate Professor

Department of Clinical Neuroscience, School of Medicine

University of North Dakota

November 28, 2016

E. Todd Tracy
The Tracy Firm
4701 Bengal Street
Dallas, TX 75235

RE: Ms. Woodlee, Ms. Pelton, and Ms. Richardson

Dear Mr. Tracy:

Pursuant to your request, I am setting forth my biomechanical opinions regarding the fatal bus accident on September 26, 2014 involving Ms. Katelynn Woodlee, Ms. Jaiden Pelton, and Ms. Megan Richardson. I am also providing a summary synopsis of my background and qualifications to render my opinions.

A. BACKGROUND AND EXPERIENCE

- Copy of CV outlining education and experience is attached.
- Professor in College of Engineering, Director of the Impact Biomechanics Laboratory and Director of Automotive Systems Laboratory, North Dakota State University (NDSU).
- Clinical Faculty and Adjunct Professor, Department of Clinical Neuroscience, University of North Dakota (UND) School Of Medicine.
- Involved in research and education in field of vehicle dynamics and biomechanics for over past 35 years.
- Research focus on human body biomechanics for last 25 years.
- Consulted, for past 25 years, in area of biomechanics, with various governmental agencies including National Highway Traffic Safety Administration (NHTSA), United States Air Force (USAF), United States Army, Department of Defense (DoD), and United States Product Safety Commission (USCPSC).
- Selected to conduct research for USAF at Armstrong Aerospace Research Laboratory (AARL)/Human Systems Division, Wright-Patterson Air Force Base (WPAFB) Dayton, OH, that included laboratory studies of entire human body responses to impact, biodynamic modeling and development of biodynamics injury criteria; and received six (6) research contracts, from USAF that involved biomechanical analysis of over 900 full scale laboratory tests with male and female pilots.
- Two (2) most current research contracts (over \$1M), supported by DoD have been in area of biomechanical analysis of injury and injury protection for US soldiers returning from combat in Iraq and Afghanistan.

- Involved for several years in Emergency Room (ER) Biomechanical Brain Injury Evaluation Research, with Fargo-Moorhead (FM) Ambulance Service and MeritCare Trauma Center, sponsored, in part, by MeritCare Foundation, Fargo, ND.
- From 2007 to present, invited to chair three (3) scientific peer review committees, as well as serve as a scientific reviewer for numerous other committees for DoD Post Traumatic Stress Disorder/Traumatic Brain Injury (PTSD/TBI) Research Program.
- Current Chairman of North American Brain Injury Society (NABIS).
- Named founding chair of Blast Injury Institute.
- Received additional specialized training with certifications in areas of Abbreviated Injury Scale (AIS) and Crash Data Analysis.
- Professor for over past 35 years, of variety of subjects in field of engineering including, biomechanics, vehicle dynamics and dynamics.
- Invited to give many national and international presentations, including ones to governmental agencies such as USCPSC.
- Published four (4) book chapters on brain and neck injury and over one-hundred (100) peer-reviewed publications.
- Fully accredited Accident Reconstructionist, Accreditation Commission for Traffic Accident Reconstruction (ACTAR #1939).

B. OBJECTIVE

To perform a biomechanical analysis of the fatal bus incident involving Ms. Woodlee, Ms. Pelton, and Ms. Richardson on September 26, 2014.

C. MATERIALS REVIEWED

1. Oklahoma Traffic Collision Report
2. CarFax Report – 2007 Chevrolet C5500
3. Plaintiff's Original Complaint
4. Plaintiff's Original Petition and Requests for Disclosure
5. Plaintiff's First Amended Petition
6. Plaintiff's Second Amended Petition
7. NCTC's First Amended Answer
8. Defendant Champion Bus Inc.'s Motions to Transfer Venue, and Subject Thereto, Original Answer and Jury Demand
9. Champion Discovery Responses
10. NTSB – Safety Recommendation and Preliminary Report Highway HWY14MH014
11. Oklahoma Department of Public Safety
12. Records of Ardmore Police Department
13. NTSB – Accident Report
14. Records of Travelers Insurance
15. Records of TASB Risk Management
16. Discovery Responses of Champion Bus Co.
17. Records re: Katelynn Woodlee
 - a. Davis Volunteer Fire Department
 - b. Springer Volunteer Fire Department
 - c. Pauls Valley Police Department
 - d. Murray County 911
 - e. Office of Chief Medical Examiner including Toxicology *and X-ray*

- f. Dodd City High School
- g. Wise Funeral Home
- h. Photographs
- 18. Records re: Jaiden Pelton
 - a. Murray County EMS
 - b. Office of Chief Medical Examiner including Toxicology *and X-ray*
 - c. Sam Rayburn High School
 - d. Cooper-Sorells Funeral Home
 - e. Photographs
- 19. Records re: Meagan Richardson
 - a. Murray County EMS
 - b. Office of Chief Medical Examiner including Toxicology *and X-ray*
 - c. Wylie ISD
 - d. Anderson Clayton Funeral Home
 - e. Photographs
- 20. Deposition of Audrey Keith Pelton
- 21. Deposition of Christie Pelton
- 22. Deposition of Ronnie W. Richardson
- 23. Deposition of Teresa I. Richardson
- 24. Deposition of Roger W. Staley
- 25. Deposition of John W. Woodlee
- 26. Letter re: Champion's Response to Request for Production – Doc 1460 - 1477
- 27. Report of Mr. Stephen Syson, The Syson Corporation
- 28. 3D FARO Laser Scans
- 29. Photographs

D. TASKS PERFORMED

For this analysis, I have done the following:

- 1. Studied the provided materials.
- 2. Determined vehicle parameters for the 2008 Champion bus and a 2013 Tractor-trailer
- 3. Inspected the subject bus on June 3, 2016
- 4. Searched and measured an exemplar bus
- 5. For Katelynn Woodlee:
 - a. Performed surrogate fit analyses in an exemplar Champion bus.
 - b. Determined the stiffness characteristics for the backrest, headrest, seat cushion and roof of the exemplar Champion bus for seat 5-D.
 - c. Determined the coefficient of friction for seat cushion of the exemplar bus seat 5-D.
 - d. Determined Katelynn Woodlee's segments' geometric and mass properties, and the joints' locations and range of motion characteristics using the Generator of Body Data (GEBOD) AL/WPAFB computer program.
 - e. Performed Katelynn Woodlee's body dynamics analysis for selected phases of event.
- 6. For Jaiden Pelton:
 - a. Performed surrogate fit analyses in an exemplar Champion bus.
 - b. Determined the stiffness characteristics for the backrest, headrest, seat cushion and roof of the exemplar Champion bus for seat 6-AB.
 - c. Determined the coefficient of friction for the exemplar bus seat 6-AB.

- d. Determined Jaiden Pelton's segments' geometric and mass properties, and the joints' locations and range of motion characteristics using the Generator of Body Data (GEBOD) AL/WPAFB computer program.
 - e. Performed Jaiden Pelton's body dynamics analysis for selected phases of event.
7. For Megan Richardson:
 - a. Performed surrogate fit analyses in an exemplar bus.
 - b. Determined the stiffness characteristics for the backrest, headrest, seat cushion and roof of the exemplar bus for seat 7 - AB.
 - c. Determined the coefficient of friction for seat cushion 7-AB of the exemplar bus.
 - d. Determined Megan Richardson's segments' geometric and mass properties, and the joints' locations and range of motion characteristics using the Generator of Body Data (GEBOD) AL/WPAFB computer program.
8. Performed Megan Richardson's body dynamics analysis for selected phases of event.
9. Reviewed 3D FARO Laser Imaging

E. ANALYSIS:

E-1 General Concept

The area of biomechanics is a component of bioengineering. The biomechanical analysis is based on the principles of physics, engineering including viscoelastic properties of tissue as well as life sciences. Impact biomechanics is the study of damage (failure) of human body regions, organs, tissue or cells as a result of sudden application of forces. The concept of damage/failure can be structural or physiological which in clinical setting is referred to as "injury" or "trauma".

One of the common objectives for a biomechanical analysis is to determine whether the injury mechanism for damage (failure) was present and whether or not the forces were sufficient to cause the damage. Biomechanical engineers do not perform clinical diagnoses they accept the diagnoses as presented in the medical records.

The procedure for biomechanical analysis (Figure 1) involves an understanding of the driving force that can be quantified in terms of generally accepted engineering parameters like change in the velocity, time duration of impact, and/or vehicle acceleration (VEHICLE DYNAMICS ANALYSIS). The quantification of impact severity from occupant perspective is the remaining portion of the biomechanical evaluation (HUMAN BODY DYNAMICS ANALYSIS). The meaning of the results from the biomechanical analysis is illustrated by comparison against the human tolerances (HUMAN TOLERANCE ANALYSIS).

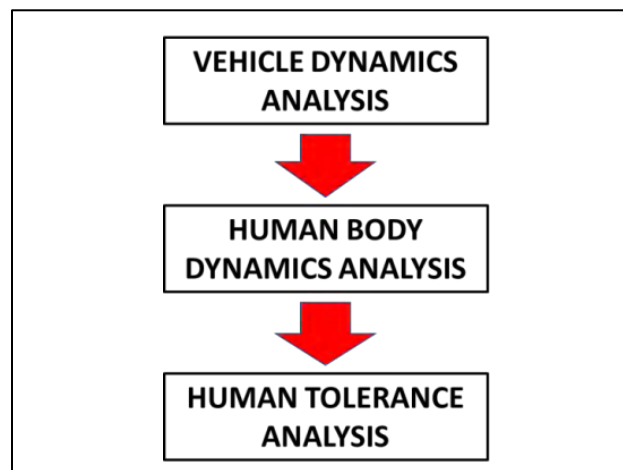


Figure 1 – Complete Procedure for Biomechanical Analysis

E-2 Accident Description

According to the narrative opinion provided in the Official Oklahoma Traffic's Collision Report (Unit 1 being the 2013 Tractor-trailer and Unit 2 being the 2008 Champion bus):

“Unit 1 was northbound on interstate 35. Unit 2 was southbound on interstate 35. Unit 1 departed the roadway to the left, crossed the grass median and entered the southbound lanes. Unit 1 struck Unit 2 in the south bound lanes. Unit continued across the southbound lanes and came to rest off the west side of the roadway. Unit 2 departed the roadway to the right and overturned a quarter time coming to rest on the passenger side.”

The officer's diagram is shown in Figure 2 (colors and labels added). The location of the incident was located on Google Earth using road names from the crash report and reference markers from scene photographs (Figure 3). Select photos (bus in original position and in righted position) taken at the scene of the accident are shown in Figures 4 and 5, with Reference “A” circled. The tractor-trailer is shown in its original position at the scene and as it was photographed post-incident (Figure 5). In Figure 6, the Google Earth image of the incident area is shown at street level with Reference “A” from Figure 4 circled. Figure 6 is a seating chart, modified from the chart provided in the NTSB report (Materials Studied #13, Page 6) with seating position provided from the Oklahoma Department of Public Safety Report (Materials Studied #11, Page 335).

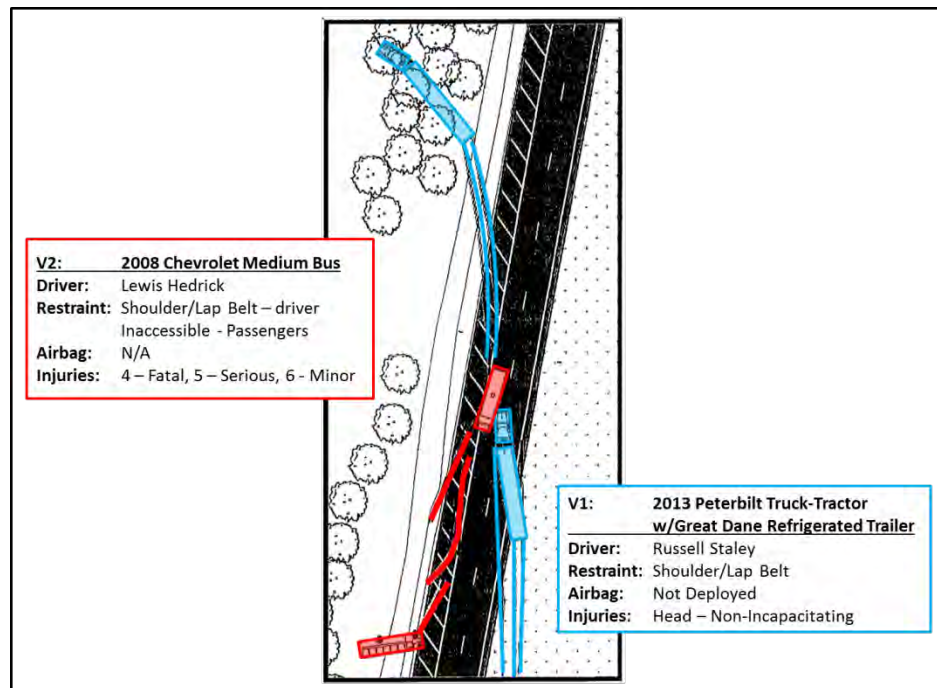


Figure 2 – Accident Diagram (Colors and Labels Added)



Figure 3 – Google Earth Image (Overview)



Figure 4 – Select Photos Taken at Scene (Bus in Original Position)



Figure 5 – Select Photos Taken at Scene (Bus in Righted Position)



Figure 6 – Select Photos of the Tractor-Trailer in its Original Position and Post-Incident



Figure 7 – Google Earth Image Street Level with Reference Circled

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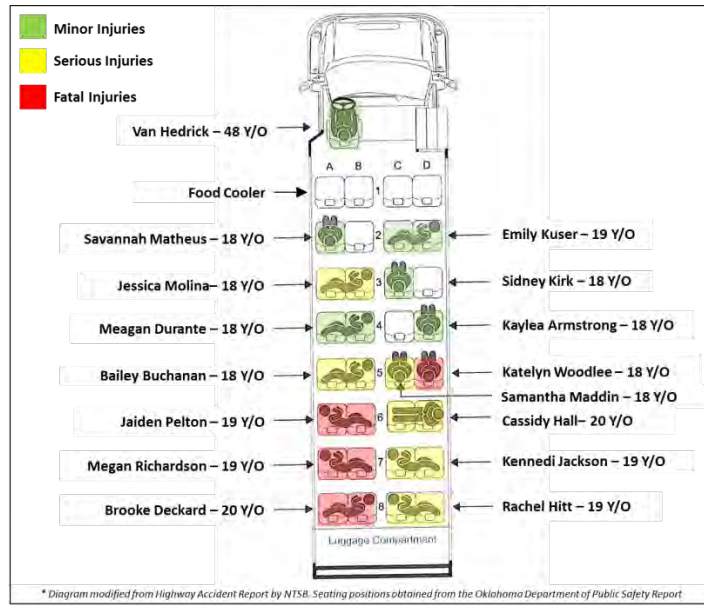


Figure 8 – Seating Chart Modified from Highway Accident Report by NTSB with Seating Provided from Oklahoma Public Safety Report

E-3 Vehicle Dynamics

E-3.1 Inspection of Exemplar bus

An exemplar bus was located. The exterior of the exemplar vehicle was measured and photographed.

E-3.2 Vehicle Damage Analysis

My inspection of the subject vehicle revealed extensive damage consistent with a left side-swipe collision, resulting in a quarter (1/4) roll. From a trauma biomechanics perspective, in this case the most relevant area of damage included, but was not limited to the entire driver's side of the vehicle. Based on the nature and extent of the Champion bus's damage, it is obvious the structural components were subjected to compressive forces exhibited by dynamic progressive buckling characteristics. The subject of dynamic progressive buckling has been extensively studied. There is a broad base of peer reviewed publications. For example:

McNay, G. H. II, "Numerical Modeling of Tube Crush with Experimental Comparison", Society of Automotive Engineers #8808

Mahmood, H. F., et al, "Design of Thin Walled Columns for Crash Energy Management – Their Strength and Mode of Collapse", Society of Automotive Engineers #811302

Mahmood, H.F. et al, "Crash Analysis of Thin Walled Beam-Type Structures", Society of Automotive Engineers #880894

Schmueser, D. W., et al, "Front Impact of Primary Structural Components of a Composite Space Frame", Society of Automotive Engineers #88090

Tundermann, J. H. Et al, "The Application of Elastometric Buckling Columns in an Energy Management Bumper System", Society to Automotive Engineers #750011

Selected references from the research work that I was personally involved in are:

Ziejewski, M., B. Anderson, M. Rao and M. Hussain, “Energy Absorption for Short Duration Impacts”, SAE Paper #961851, Indianapolis, IN 1996

Ziejewski, M., B. Anderson, “The Effect of Structural Stiffness on Occupant Response for A –Gx Acceleration Impact”, SAE Paper #962374, Sao Paulo, Sp, Brazil, 1996.

Ziejewski, M, H. Goettler, “Effect of Structural Stiffness and Kinetic Energy on Impact Force”, SAE Paper #961852, Indianapolis, IN, 1996

Anderson, B., M. Ziejewski, H. Goettler, “Method to Predict the Energy Absorption Rate Characteristics for a Structural Member”, SAE Paper #982388, Detroit, MI, 1998

Pan, X., M. Ziejewski, H. Goettler, “Force Response Characteristics of Square Columns for Selected Materials at Impact Loading Combinations Based on FEA”, SAE #982418, Detroit, MI, 1998.

The damage assessment for the Champion bus was carried out using two different approaches: laser based measurements and basic measuring tools. Selected images from the 3D FARO Laser System are shown in Figure 10. Example photographs taken during my inspection, with exterior measurements suitable for photogrammetric analysis are shown in Figure 11.



Figure 10 – 3D FARO Laser Image for the 2008 Champion bus



Figure 11 – Selected Photos of 2008 Champion bus

I would like to provide additional information regarding the methodology used for the photogrammetry. The technique is based on the principle of technical drawing, geometric constructions and drawing

perspectives. Photogrammetry is well known and recognized in engineering in general and in accident reconstruction including determination of the vehicle deformations. Part of the process involves superimposing the undeformed vehicle with a scale that will overlay the photograph depicting the deformed vehicle. The textbook “Technical Drawing” was, for many years, the choice textbook for many engineering colleges throughout the United States. Personally, I taught from this textbook for many years as well. It states, “this method utilizes actual photographs of the earth’s surface and of man-made objects on the earth....it issued for such activities as governmental and commercial surveying...It has the great advantage of being easy to use....”. “...it is possible not only to determine the relative positions of objects in a horizontal plane, but it is also possible to determine relative elevations.” Photogrammetry is also widely accepted in the Automotive Engineering Community. Peer reviewed articles are:

Kerkhoff, John F., “Photographic Technique for Accident Reconstruction”, Society of Automotive Engineers #850248, 1985.

Gillen, Larry, “Photogrammetric Mapping of Vehicle Deformation”, Society of Automotive Engineers #861421, 1986.

This method is widely accepted in the traffic accident investigation field. In “The Traffic Accident Investigation Manual – At Scene Investigation and Technical Follow-Up”, topic 830 is titled “Photogrammetry for Traffic-Accident Investigation.” There is also an example from the Accident Reconstruction Journal informing the readers about computerized photogrammetry techniques for assessment of vehicle damage.

The more current photogrammetry techniques I utilized are described and validated in the following SAE publications:

Chou, C., et al, “Image Analysis of Rollover Crash Test Using Photogrammetry”, Society of Automotive Engineers #2006-01-0723, 2006.

Fenton, S. et al, “Determining Crash Data Using Camera-Matching Photogrammetric Technique”, Society of Automotive Engineers 2001-01-3313, 2001.

Photogrammetry error rates in vehicle damage mapping are well within 5% and will depend only on the ability of the person being able to read the ruler accurately.

Most of the driver’s side outer panels and insulation were ripped away from the vehicle frame (Figure 12). The glass in all but one window on the driver’s and passenger’s side of the bus was broken or missing, creating large ejection openings (Figure 13). According to Mr. Syson’s report, (Materials Studied #27, Section VIII, H-O), welding joints between the seat and side structure of the bus appear to be weak, unreinforced, and did not extend below the floor, thus, reducing the integrity of the bus frame. The “unistrut” seat support channels were connected to the seats by flat plates (Figure 14). Only lap-belts were available to the passengers of the bus but were difficult to use due to difficult accessibility, entanglement, length, and significant wear (Figure 15). The rear cargo door did not stay closed during the impact, removing important diagonal bracing needed for the frame of the bus to remain square (Figure 16).



Figure 12 – Driver Side Damage and Intrusion



Figure 13 –Improperly Tempered Glass Displaced Driver's Side Windows



Figure 14 – Inadequately Secured “Unitstrut” Seat Support



Figure 15 – Lap-Only Belts Were Difficult to Use, Tangled, Lacked Proper Length and Showed Wear



Figure 16 – Lack of Diagonal Bracing From Open Cargo Door

Conclusion: The passengers of the bus were provided only the use of lap belts which were not easily accessible and in some cases, damaged. Large openings were created through which passengers were fully or partially ejected due to lack of structural integrity and improperly tempered glass (according to Mr. Syson’s report, Section VII, V).

E-3.3 Vehicle Kinematics

1. The 2013 tractor-truck was northbound on I-35.
2. The 2008 Champion bus was southbound on I-35.
3. The tractor-truck, for unknown reasons, crossed the grass median into southbound traffic.
4. The tractor-truck side-swiped the Champion bus along its driver’s side, resulting in a slight counterclockwise rotation of the bus.
5. The Champion bus tips and comes to rest on its passenger’s side

E-4 Human Body Dynamics

Human body dynamics analysis requires a thorough understanding complex interaction between different parameters including but not limited to change in velocity (ΔV), direction and duration of impact, gender, height, weight, body position and others. For several decades many research publications have addressed the complexity of the response of visco-elastic nature of the human body under a variety of loading conditions. As a part of my research work at the Armstrong Aerospace Research Laboratory at Wright Patterson Air Force Base, I have been personally involved in the analysis of more than nine hundred (900) tests with male and female pilots under different loading conditions.

In all three (3) girls’ case, I performed an analysis using engineering principles and methodologies generally accepted in the scientific community. Example references are listed below:

Hibbeler, R.C., “Engineering Mechanics – Dynamics”, Twelfth Edition, Pearson Prentice Hall, Pearson Education, Inc. 2010

Nahum, A., Gomez M., “Injury Reconstruction: The Biomechanical Analysis of Accidental Injury”, Society of Automotive Engineers, #940568.

Robbins, D.H., et al, “Biomechanical Accident Investigation Methodology Using Analytic Techniques”, Society of Automotive Engineers, #831609.

The overall (resultant) forces/accelerations acting on different body parts are the cumulative effect of forces along and about the three axes’. A graphical illustration of the six force components in three directions is presented in the Figure 17.



Figure 17 – Types of Forces

E-4.1 Interior Measurements and Surrogate Fit

The interior of the exemplar vehicle were measured and photographed. The stiffness and friction characteristics of the three seats were determined. The following tests were performed (using Figure 8 seating chart for reference):

- Force deflection of the roof using the occipital plate
- Force deflection for seat 5-D headrest using occipital plate
- Force deflection for 5-D backrest using test plunger
- Force deflection for 5-D seat cushion using test plunger
- Coefficient of friction

- Force deflection of the roof using the occipital plate
- Force deflection for seat 6-AB headrest using occipital plate
- Force deflection for 6-AB backrest using test plunger
- Force deflection for 6-AB seat cushion using test plunger
- Coefficient of friction

- Force deflection of the roof using the occipital plate
- Force deflection for seat 7-AB headrest using occipital plate
- Force deflection for 7-AB backrest using test plunger
- Force deflection for 7-AB seat cushion using test plunger
- Coefficient of friction

In the above listed testing, the following equipment was used:

- Dillon Force Gauge BFG 2500N, Serial Number 05-0257-04, Certificate Number 516385
- Occipital Plate – Skull Cap, Machined, Part Number 78051-221; Skin, Cap Skull – Part Number 78051-229

One surrogate similar in height and weight to all three was utilized to represent each girl in the different seats. The objective of the surrogate fit (Figure 18-20) was to relate geometrical dimensions of the 2008 Champion bus to each girl.



Figure 18 – Surrogate Fit in Exemplar Bus, Seat 5-D (Katelynn Woodlee)

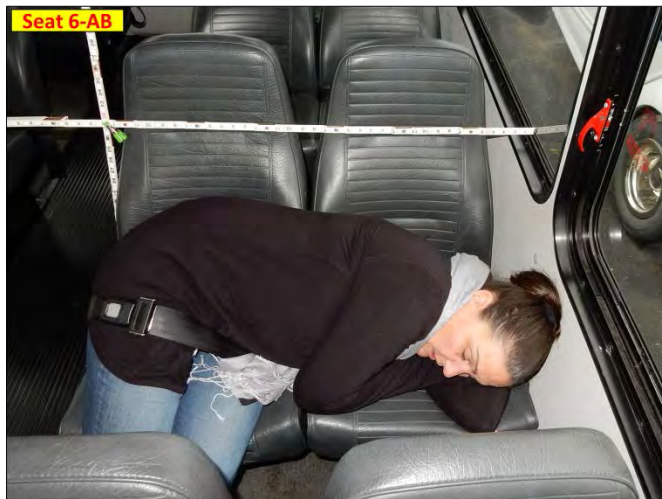


Figure 19 – Surrogate Fit in Exemplar Bus, Seat 6-AB



Figure 20 – Surrogate Fit in Exemplar Bus, Seat 7-AB

The GEBOD (AL/WPAFB) computer program was used to generate the body description for Ms. Katelynn Woodlee, Ms. Jaiden Pelton and Ms. Megan Richardson's anthropometry.

Table 1 depicts the difference between the GEBOD seated height output of each subject girl and the selected surrogate. Additionally, GEBOD output data set includes the body segments' geometric and mass properties and the joints' locations and range of motion characteristics that allows for detailed dimensional comparisons. Only the surrogate height in comparison to Mr. Woodall is of relevance in static geometrical fit.

Table 1 – Difference between GEBOD seated height output of subject vs surrogate

SUBJECT NAME	SUBJECT HEIGHT	SUBJECT SEATED HEIGHT	SURROGATE SEATED HEIGHT	DIFFERENCE
Katelynn Woodlee	65 inches	34.60 inches	33.89 inches	-0.71 inches
Jaiden Pelton	64 inches	33.97 inches	33.89 inches	-0.08 inches
Megan Richardson	63 inches	33.44 inches	33.89 inches	+0.45 inches

E-4.2 Medical Records / Biomechanical Perspective:

A review of the medical records was performed to assess Ms. Woodlee, Ms. Pelton and Ms. Richardson's injury patterns. Figure 21-23 is a brief summary of their injuries as documented in their medical records. For a complete description of the injuries please see all medical records.

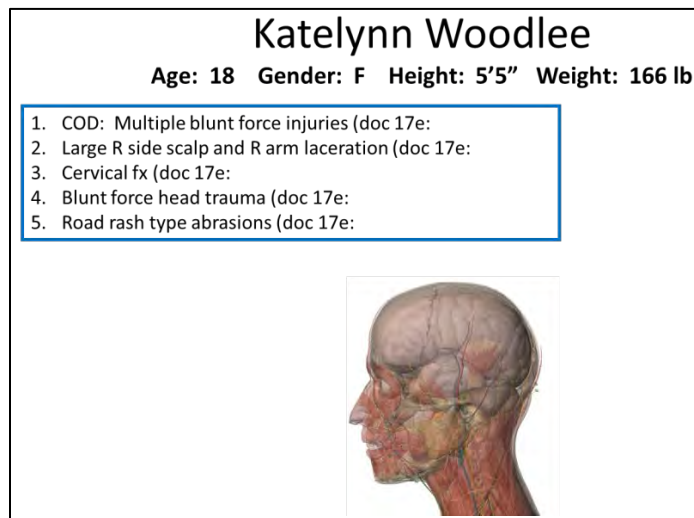


Figure 21 - Injury Pattern Analysis (Katelynn Woodlee)

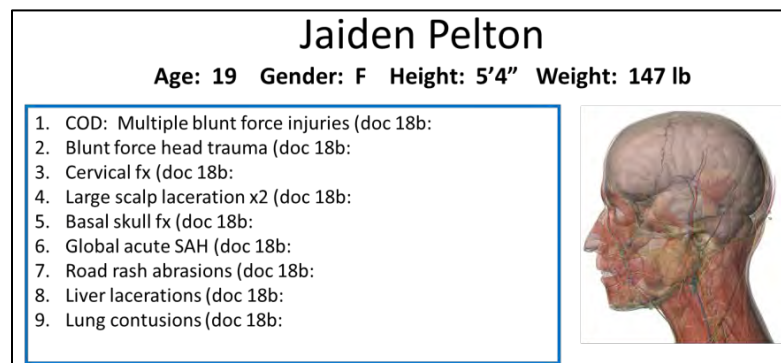


Figure 22 – Injury Pattern Analysis (Jaiden Pelton)

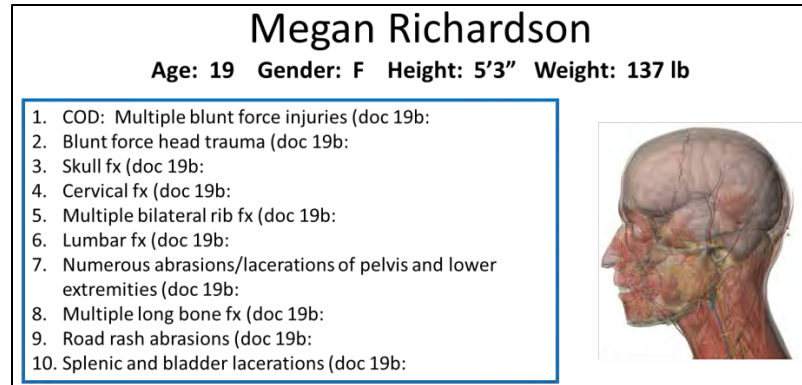


Figure 23 – Injury Pattern Analysis (Megan Richardson)

The biomechanical assessments of all three girls' injuries are consistent with bodily trauma resulting from a combination of linear and angular forces/accelerations as a consequence of their body interaction with the internal vehicle components and external environment resulting from ejection.

The severity of injury was evaluated based on an Abbreviated Injury Scale (AIS, 2008). The AIS scale includes ratings from 1-6 (Level 1-Minor, Level 2- Moderate, Level 3 – Serious, Level 4 – Severe, Level 5 – Critical, and Level 6- Maximal).

Abbreviated Injury Scale (AIS) 2005, Association for the Advancement of Automotive Medicine (AAAM), Update 2008.

As a result of the incident on September 26, 2014 each of these girls did not survive their injuries and were partially ejected (Ms. Woodlee) or fully ejected (Ms. Pelton and Ms. Richardson) from the safety of the vehicle.

Most likely the sequence of events for Ms. Pelton and Ms. Richardson would be nearly identical. Although their exact seated position is not certain, interviews state they were located on the driver's side of the bus, lying down. Multiple blunt force injuries, cervical fractures, internal organ lacerations and contusions are indicative of contact with the intruding bus wall, and/or the tractor-truck itself, during the initial side-swipe impact. Fractures, lacerations and road rash abrasions are consistent with injuries received during ejection and subsequent sliding along a paved surface.

Ms. Woodlee was sitting on the passenger side of the bus and most likely was not seriously injured during the initial side-swipe impact of the tractor-trailer. However, Ms. Woodlee's injuries are consistent with partial ejection and the tipped bus coming to rest on her head and shoulders.

E-4.3 Human Body Kinematic / Kinetics

On September 26, 2014, Ms. Woodlee, Ms. Pelton and Ms. Richardson were involved in a side-swipe collision which resulted in a slight counter clockwise rotation as the vehicle tipped onto its passenger's side. The last phase must be considered a quarter roll (1/4) event. Maintaining the occupant's body within the seat perimeter is beneficial and can be achieved through known design features like readily accessible restraint systems and ejection mitigation glass.

National Highway Traffic Safety Administration (NHTSA) Advanced Glazing Research Team, "Ejection Mitigation Using Advanced Glazing: Final Report", 2001.

Batzer, S.A., G. Herndon, P. Semones, C. Thorbole, M. Ziejewski and R. Hooker, "Automotive Side Glazing Ejection Mechanisms, Part I – Model Development, IMECE2008-68482

Batzer, S.A., G. Herndon, P. Semones, C. Thorbole, M. Ziejewski and R. Hooker, "Automotive Side Glazing Ejection Mechanisms, Part II – Review of Recent Glazing Literature, IMECE2008-68483

Thorbole, C. and S. Deshpande, "A Study to Address the Failure Mechanism of the Conventional 3-Point Restraint in Protecting the Far Side Occupant in a Rollover Accident", Society of Automotive Engineers, 2015-26-0161

Ms. Pelton and Ms. Richardson's body motion would have been toward the Principle Direction of Force (PDOF), forwards and towards the driver side of the bus. As the bus was impacted, the sidewall was torn away, and their unrestrained bodies were ejected from the bus most likely contacting and sliding/rolling from the pavement to their final resting position 15-20 ft. north of the bus and west of the paved shoulder.

Ms. Woodlee was seated upright in row 5 of the bus next to the window on the passenger's side. Her body motion would have been slightly forward and left as the bus was impacted. The impact between the passenger side of the bus and the ground forced her body motion back to the right and become partially ejected through the window she was seated against. As the Champion bus bounced, her head and right shoulder became trapped between the bus and ground.

It must be noted the known limitations of the lap-only belt configuration result in providing ineffective upper body restraint of the occupants in the subject incident vehicle kinematics. Ms. Woodlee, Ms. Pelton, and Ms. Richardson would not have been protected by the available lap-only seatbelts.

Conclusion: Had the Champion bus provided adequate safety systems, including but not limited to; a solid frame structure which would deflect the impacting vehicle, accessible 3-point safety belts, and ejection mitigation glass, none these girls' injuries would have been fatal, like the occupants who were not ejected from the bus or the driver who was properly belted.

F. ALTERNATIVE DESIGN ANALYSIS

According to Mr. Syson's report, suggested safer alternative designs include, but are not limited to:

1. Improvement in structural design allowing better energy absorption and deflection of the striking vehicle (Pg 11 VIII, F)
 - a. Strengthen pillar attachments with proper welding and reinforcement (Pg. 11, Section VIII. H)
 - b. Structure at bumper level of striking vehicle to deflect striking vehicle around wheels and tires (Pg. 12, Section VIII, F & J)
 - c. Structures which feed loads into the floor (Pg. 12, VIII, O)
 - i. Strong under floor cargo boxes
 - ii. Utilize seat structures which transmit load across the bus and into the floor
 - d. Strengthen side structures (Pg. 24, Section IX, O)
 - i. Moving the cargo area from the very back of the bus to the area under the seats
 - e. Require both sides of the roof structure to participate energy absorption even if only one side of the roof is impacted (Pg. 16, Section VIII, NN-SS)
 - i. Design roof to include transverse members in front and rear headers to transmit loads
2. Utilize ejection mitigation glass (Pg. 19, Section IX))
3. Provide seatbelts, preferable 3-point safety belts, which are designed to stay above the seat cushions and accessible during normal conditions (Pg. 22 & 23, Section X, F & L)

- a. Incorporate guides for the seatbelt assemblies to pass through
- b. Integrate 3-point safety belts on buses

Based on my education, training and experience as well as my knowledge of testing of these principles, I can state that these safer alternative design features would have prevented the injuries sustained by the three girls. Specifically, had the roof and side structures of the bus remained intact, occupants would have been contained within the vehicle. Had the bus contained ejection mitigation glass, large openings through which passengers were either partially or fully ejected would have been eliminated. Accessible, appropriately fitting or 3-point safety belts would have allowed passengers to be restrained in their seats and would have prevented injuries sustained from being ejected from the Champion bus.

Researchers have written that the risk of fatal injury is increased by a factor of 91 in occupants who are ejected during a rollover event. FARS data has shown that 47 percent of occupants killed in rollovers have been ejected from the vehicle. FARS data also shows that preventing ejection is associated with a 64 percent decrease in the risk of death. Preventing ejection is one of the fundamental principles of crashworthiness.

Conclusion: Had the safer alternative designs features been implemented in the 2008 Champion bus, Ms. Woodlee, Ms. Pelton, and Ms. Richardson's injuries would have been less severe and certainly not fatal as were seen by the fact that all the other occupants were able to self-extricate from the bus.

G. ANTICIPATED DEFENSES

1. *Defense may claim it did not cause the accident.*

While the defense did not cause the incident, it did fail to provide functioning safety systems which were the direct cause of Ms. Woodall, Ms. Pelton and Ms. Richardson's ejection and fatal injuries.

2. *Defense may claim the incident was too severe for the Champion bus to provide occupant protection.*

This is incorrect. The bus experienced a center of gravity acceleration within human tolerance level as seen by the less severe injuries of the bus driver, and the additional 11 passengers. This was a side swipe impact, not a side impact type accident event. The crash forces were over a long duration and were not injurious. The fatal injuries resulted from structure failure and large ejection openings created.

3. *Defense may claim adequate structure or appropriate/accessible restraints are not related to Ms. Woodlee, Ms. Pelton, and Ms. Richardson's injuries.*

This is incorrect. The fatal injuries suffered by the three girls are consistent with injuries sustained as a result of an ejection event. Injuries not associated with the ejection event were survivable. Designs which provided a safer environment and prevented ejection would have reduced the risks of fatal or serious injury to Ms. Woodall, Pelton and Richardson.

4. *Defense may argue the 3 girls are to blame for not wearing their available lap belt.*

This is incorrect. First, the bus was not even required to contain any type of seatbelts. Second, millions of students each day ride on buses which do not contain lap and 3-point belts. Third, as the NTSB reported, Oklahoma and Texas do not require passengers to utilize seatbelts on buses. Fourth, even if the lap belts had been utilized, the risk of partial ejection through the large glass openings would still likely have resulted in fatal injuries since the glass openings were so large.

H. OPINIONS

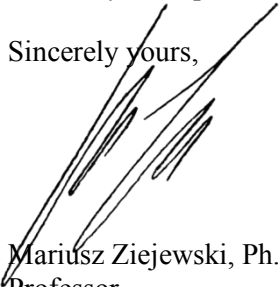
All of my opinions and conclusions throughout this report are given to a reasonable degree of engineering, biomechanical and scientific certainty.

1. **As a result of the incident on September 26, 2014, the subject 2008 Champion bus experienced center of gravity (CG) acceleration that would have been within the human tolerance level.**
2. **The driver of the 2008 Champion bus was properly seated and belted; however Ms. Woodlee, Ms. Pelton and Ms. Richardson available lap-only belts were difficult to access.**

3. **Lack of structural integrity and ejection mitigation glass created large openings through which passengers were fully or partially ejected.**
4. **The biomechanical assessments of Ms. Woodlee, Ms. Pelton and Ms. Richardson's injuries are consistent with fatal injuries occurring outside the safe confines of the bus following ejection.**
5. **Known limitations of the lap-only belt configuration would result in providing ineffective upper body restraint of the occupants in the subject incident vehicle kinematics. Ms. Woodlee, Ms. Pelton, and Ms. Richardson would not have been saved by the available lap-only seatbelts.**
6. **The cause of the fatal injuries to the 3 girls are consistent with ejection from the bus.**
7. **Had the Champion bus provided adequate safety systems which prevent ejection, including but not limited to; a solid structure which would deflect the impacting vehicle, easily accessible 3-point safety belts, and ejection mitigation glass, these girls would not have suffered fatal injuries and most likely would have experienced less than serious injuries, much like their fellow players who remained inside the bus.**

I reserve the right to amend this report, to modify, change and/or to alter my opinions predicated upon further discovery and upon receipt of any additional materials.

Sincerely yours,



Mariusz Ziejewski, Ph.D., Inż.

Professor

Director of Impact Biomechanics Laboratory, College of Engineering

Director of Automotive Systems Laboratory, College of Engineering

North Dakota State University

and

Clinical Faculty

Adjunct Associate Professor

Department of Clinical Neuroscience, School of Medicine

University of North Dakota