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October 8, 2014

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New York City Transit Authority  
Office of the General Counsel  
130 Livingston Street, Room 1110-G  
Brooklyn, New York 11201-5190

Subject: Shillingford v. NYCTA, et al.  
Project No. 1404779.EX0

Dear Ms. Bonnick:

In accordance with your request, Exponent has conducted a biomechanical investigation of the November 23, 2011 motor vehicle collision involving Ms. Melissa Shillingford. The purpose of this investigation was to evaluate Ms. Shillingford's occupant kinematics and the forces brought to bear upon her neck and lower back during the subject incident, and to assess whether the subject incident was biomechanically related to the cervical and lumbar spine pathologies identified in her medical records.

## Materials Received

The following materials have been received and reviewed.

- Verified Bill of Particulars dated November 12, 2012
- Supplemental Verified Bill of Particulars dated April 25, 2013
- New York City Transit Authority's response to plaintiff's Combined Demands, dated November 26, 2012
- Transcript of Examination before Trial of Melissa Shillingford dated September 30, 2013
- Transcript of Examination before Trial of Tony Beetan dated September 30, 2013
- Medical records of Melissa Shillingford
- New York State Department of Transportation Police Accident Report, dated November 23, 2011
- Claim Against NYC Transit for Property Damage, dated January 13, 2012

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- New York City Transit Supervisor's Accident/Crime Investigation Report, dated November 23, 2011
- New York City Transit Accident Description Report, dated November 23, 2011
- New York City Transit Operators Accident report and Daily Trip Sheet, dated November 23, 2011
- West Farms incident report for accident of November 23, 2011
- Color photocopies of photographs (8) of 1997 Honda Accord with VIN 1HGCD565XVA062669 taken by Mercury Adjustment Bureau on inspection of February 22, 2012
- Repair estimates for 1997 Honda Accord with VIN 1HGCD565XVA062669 by Mercury Adjustment Bureau, per inspection of February 22, 2012
- Bus History Report (Spear-by Date Range), November 23, 2010 to November 23, 2011
- Bus Maintenance History (MIDAS), November 23, 2010 to November 23, 2011

## Incident Summary

According to the New York State Department of Transportation Police Accident Report, the subject incident occurred at 10:47 A.M. on November 23, 2011, on the Cross Bronx Expressway at the intersection of Beach Avenue in Bronx, New York. Lighting conditions were coded as "daylight," the weather was "rain," and the roadway was coded as "straight and level" and "wet." At that time and location, Melissa Shillingford, age 23, was driving a 1997 Honda passenger vehicle<sup>1</sup>, and Tony Beetan, age 47, was driving a 2003 Orion bus.<sup>2</sup> The vehicles were both traveling east. Both drivers were listed as wearing a lap belt and harness.

According to the police report narrative, Ms. Shillingford was stopped at a traffic light and the bus hit her from behind in a rear end collision. The initial point of impact and principal damage was to the rear center of the Honda and front center of the bus. The police report noted no other points of damage to either vehicle. Similarly, various NYCT accident reports indicated a rear-end impact in which the front of the bus struck the rear of the Honda.

Apparent contributing circumstances for the incident were coded as "driver inattention/distraction" for the bus. "Pre-accident vehicle action" was listed as "stopped in traffic" for the Honda and "going straight ahead" for the bus. According to the police report, the "type of physical complaint" for each driver was "none."

The police report listed no passengers in either the Honda or the bus. However, the NYCT Operator's Accident report indicated six passengers on the bus, all uninjured. Similarly, the

<sup>1</sup> A decode of the vehicle identification number (VIN) identified it as a 1997 Honda Accord EX.

<sup>2</sup> A decode of the vehicle identification number (VIN) identified it as a 2003 Orion VII LNG (liquid natural gas) 40-foot bus

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NYCT Supervisor's Accident/Crime Investigation report indicated the presence of six customers with no injuries. The West Farms bus depot report indicated four total customers with no injuries.

### **Examination before Trial Testimony of Melissa Shillingford**

According to her examination before trial testimony, Ms. Shillingford was driving a 1997 Honda Accord north on the Cross Bronx Expressway. She was stopped at a red light and impacted by the Transit Authority bus. Ms. Shillingford testified that her vehicle moved approximately 50 feet forward as a consequence of the impact. She stated that she was wearing her seat belt, that her head came into contact with the steering wheel, and that she lost consciousness. She testified that she sustained no cuts or lacerations from the impact with the steering wheel, but that she did break her two upper front teeth. Police arrived at the scene and offered Ms. Shillingford an ambulance, which she declined. Her husband picked her up from the accident scene. The Honda was driven to her home by a family member after the accident.

Ms. Shillingford reported that she had neck and back pain and headaches after the subject incident. She stated that she went for medical treatment approximately four hours after the accident. She testified that the doctor she saw that day at Prestige Medical Center prescribed Advil and physical therapy, which she began immediately, three to four times per week. On each visit she received chiropractic, massage and acupuncture treatments. She stated that she received treatment at Prestige Medical at this frequency for more than six months. She also testified that after an MRI study of her spine was performed, her physical therapy treatments increased to five times per week.

### **Examination before Trial Testimony of Tony Beetan**

Mr. Beetan was the operator of the bus in the subject accident. He testified that the accident occurred on the service road of the Cross Bronx Expressway at the intersection with Taylor Avenue and/or Beach Avenue.

Mr. Beetan testified that before the impact, the Honda was stopped at a traffic light. Mr. Beetan observed the light to be green and honked his horn to alert the driver of the Honda of the light change when the bus was about 20 feet from the rear of the Honda, then he applied hard braking. Mr. Beetan testified that he was traveling at about five miles per hour when he used the horn at the distance of 20 feet from the Honda and that he was traveling at about five miles per hour at the moment of impact. He testified that the bus did not skid prior to impact and that the bus stopped upon impact. Mr. Beetan testified that after the impact, the driver of the Honda "took off" and drove approximately 200 feet straight ahead.

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## Medical Records of Melissa Shillingford

Melissa Shillingford's pre-incident medical history was significant for a seizure disorder for which she was taking anti-epileptics. Ms. Shillingford also reported to her physicians a history of being in a minor collision in September of 2011, prior to the date of the subject accident.

An Initial Comprehensive Medical Examination form from Prestige Medical, P.C., dated November 28, 2011, recorded that Ms. Shillingford presented for medical treatment five days after the subject incident with chief complaints of neck pain without upper extremity radiation, lower back pain without lower extremity radiation, and right foot cramping.<sup>3</sup> Physical examination revealed moderate tenderness of the cervical muscles with decreased range of motion of the cervical spine and moderate paraspinal muscle tenderness and spasms with decreased range of motion of the lumbosacral spine. She was diagnosed with cervical sprain/strain and lumbosacral sprain/strain.

On follow up examination of December 20, 2011, Ms. Shillingford reported that her neck pain was improving and the right foot tingling had stopped, but she complained during this visit of constant headaches, which were not indicated in her previous examination, and lower back pain. She also presented with a complaint of chipped right front incisors, which was not reported in records of her initial examination five days after the subject incident.

Ms. Shillingford presented to Mohamed Nour, M.D., on December 28, 2011, for an orthopedic consultation with complaints of headaches, neck pain and lower back pain. Dr. Nour diagnosed acute cervical sprain/strain post trauma, acute lumbar sprain/strain post trauma and "posttraumatic headaches syndrome." Dr. Nour's patient history also indicated no loss of consciousness in the subject incident.

Prestige Medical records indicate that a head CT study performed December 30, 2011, was read as unremarkable. The dictated radiologist's report is not available for review.

On January 3, 2012, x-ray studies of Ms. Shillingford's cervical and lumbar spine were read as negative by Sung Uk Kim, M.D. An MRI study of Ms. Shillingford's lumbar spine performed January 10, 2012, was read by Dr. Jon Lerner, as revealing a mild diffuse disc herniation with mild effacement of the thecal sac at the L4-L5 level. At the L5-S1 level, Dr. Lerner also noted a mild diffuse disc herniation eccentric to the right with mild effacement of the thecal sac and mild right-sided neural foraminal narrowing. Medical records indicate that an MRI study of the

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<sup>3</sup> Prestige Medical records indicating that Ms. Shillingford's initial medical treatment was on November 28, 2011, five days after the subject incident, are supported by orthopedic consultation notes from a December 28, 2011 examination, which record that Ms. Shillingford did not seek medical care at any hospital on the day of the accident, and by the February 14, 2012 records of Dr. Ronald Mann, which again indicate that Ms. Shillingford did not seek medical emergency care immediately following the subject incident.

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cervical spine was performed on the same day. The radiologist's report for that study is not available for review.

Ms. Shillingford presented to Max Jean-Gilles, M.D., on February 6, 2012, for a neurologic examination with complaints of headaches and constant back pain which radiated to the right buttock. Dr. Jean-Gilles documented that Ms. Shillingford had full active range of motion of the neck without tenderness. He noted moderate paraspinal tenderness along the lumbar spine, particularly between the L4-L5 and L5-S1 levels. Electrodiagnostic studies performed the same day revealed evidence of bilateral L5 radiculopathy.

On February 14, 2012, Ms. Shillingford presented to Ronald Mann, M.D., for an orthopedic examination with complaints of constant headaches, sensitivity to tooth damage, and pain in her mid and low back. Dr. Mann noted that Ms. Shillingford's cervical and thoracic spine sprains had resolved and that her lumbar spine sprain/strain was resolving. He commented that Ms. Shillingford was permitted to carry out activities of daily living as she had been prior to the accident and that she had no orthopedic disability. Included in Ms. Shillingford's prior accident and surgical history were broken teeth sustained in a prior accident and a prior appendectomy.

Ms. Shillingford presented to Andrew Merola, M.D., on August 6, 2012, for an orthopedic spine evaluation with complaints of persistent low back pain with radiating pain. After reviewing the MRI scans of the cervical and lumbar spine from January 10, 2012, Dr. Merola diagnosed herniations at the C4-C5, C5-C6 segments and a predominant herniation at the L4-L5 segment.

Arden Kaisman, M.D., examined Ms. Shillingford on August 16, 2012. Dr. Kaisman diagnosed herniated discs at L4-L5 and L5-S1 with lumbar radiculopathy and myofascial pain syndrome.

According to the medical records, Ms. Shillingford was 23 years old at the time of the subject incident, 5 feet 5 inches tall and weighed 150 pounds.

## Analysis

The incident of November 23, 2011, was evaluated from a biomechanical perspective to assess the occupant kinematics of Melissa Shillingford and the forces on her neck and back during the subject incident, and to determine whether this incident provided a mechanism for her cervical and lumbar spine pathologies, as documented in her medical records. This analysis first involved an engineering analysis of the collision based upon the material provided regarding the subject incident (as listed in the beginning of the report); the laws of physics; engineering knowledge regarding vehicle structures and their structural deformation in response to impact forces; and vehicle specifications. The collision was then examined in the context of what has been learned from crash tests regarding occupant kinematics and loads experienced by

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occupants' bodies and from biomechanical studies of human tissue mechanics and tolerance to forces. This analysis also involved a detailed review of Ms. Shillingford's medical records.

Photographs of the Honda show scratches to the rear bumper cover. A repair estimate dated February 23, 2012, detailed rear damage to the Honda Accord as including damage to the rear bumper assembly and to the muffler and pipe of the Honda's exhaust system. The New York City Transit Supervisor's Accident/Crime Investigation Report recorded the damage to the Honda as marks and cuts on the rear bumper and noted that the trunk would not close. The New York City Transit operator's report dated November 23, 2011, and signed by Tony Beetan listed the damage to the Honda as a paint scratch of the rear bumper. Damage to the bus was listed in the New York City Transit Supervisor's Accident/Crime Investigation Report as scuff marks on the front center of the front bumper. These findings are consistent with the police report of the subject incident, which indicated the center rear as the only location of damage to the Honda and the center front as the only location of damage to the bus.

The February 23, 2012 repair estimate for the Honda Accord additionally and separately listed front end damage, and an estimate from Japs Auto Clinic, dated December 30, 2011, listed both rear and front end damage to the vehicle. Photographs of the Honda Accord from the inspection of February 23, 2012, showed damage to the left front fender of the vehicle, including the head lamp, marker lamps and front bumper cover. These left front corner and fender damages to the Honda are inconsistent with the subject collision. Based on the available evidence, the Honda was impacted in the rear from the bus. There is no indication that a subsequent frontal impact to the Honda occurred. While the available testimony discussed the rear impact, there is no indication of any frontal impact to the Honda Accord. The accident is furthermore described as a rear impact in the Police Accident Report, the West Farms incident report, the Claim Against NYC Transit for Property Damage, the New York City Transit Supervisor's Accident/Crime Investigation Report, the New York City Transit Accident Description, and the New York City Transit operator's report. None of these reports, including the police report, made any indication of any damage to the left front fender of the Honda in relation to the subject incident. It is noteworthy that a CARFAX report for the Honda Accord indicated a left side impact with another vehicle on September 21, 2011, approximately two months prior to the subject incident. This September 2011 motor vehicle collision, which is also referenced in Ms. Shillingford's medical records as a prior accident (possibly the "prior accident in which she sustained broken teeth"), is consistent with the left front corner and fender damage of the Honda Accord.

When two vehicles collide, the transfer of momentum results in a change in velocity of both vehicles, generally with the struck vehicle accelerating, or speeding up, and the striking vehicle decelerating, or slowing down. In the absence of intrusion into the occupant compartment space, the vehicle's change in velocity during the impact, referred to as the delta-V, is an effective indicator of the severity of the collision for the vehicle's occupants. The damage to each vehicle indicates that in the subject collision, the front bumper of the bus driven by Mr. Beetan struck

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the rear bumper of the Honda. According to Ms. Shillingford's and Mr. Beetan's testimony, the Honda was stopped when the collision occurred.

As noted above, in the absence of intrusion into the occupant compartment, a vehicle's delta-V is an effective indicator of the severity of the collision for the vehicle's occupants. A vehicle's delta-V in a collision can be determined by quantitative analysis of damages to the vehicle. The damage estimate for the rear of the 1997 Honda Accord due to the November 23, 2011 collision lists replacement of the rear bumper assembly and replacement of the muffler and exhaust pipe. The damage to the rear of the Honda can be used in a crush energy analysis assuming actual permanent crush deformation of vehicle structures. When physical damages to a vehicle are minimal and primarily engage non-structural vehicle components, a crush energy analysis can provide an upper bound estimate for the severity of the subject collision. Using a crush energy analysis, the delta-V of Ms. Shillingford's Honda can be bounded at less than nine miles per hour. Again, this estimate sets an upper bound for the delta-V experienced by the Honda. Among other things, it takes into consideration a possibility of two inches of hidden crush deformation to rigid vehicle structures under the plastic bumper cover. The available photographs and the repair estimate give no indication that such a degree of crush occurred. To the extent that vehicle structures were permanently crushed less than this amount, the actual delta-V the Honda experienced in the subject collision was most likely much less than this upper bound of nine miles per hour.

Prior to a collision, a stopped vehicle and its occupants are essentially both at rest with respect to the ground. If collision forces change the velocity of the vehicle from its original stationary condition, its occupants initially remain at rest. The discrepancy between the velocity of the moving vehicle and the stationary occupants results in movement of the occupants relative to the vehicle interior. This movement continues until it is arrested via interaction with the restraints like seat belts and/or interaction with interior vehicle structures like seat cushions and head restraints. In the subject incident, Ms. Shillingford experienced a rear-end collision, in which the occupant compartment of the Honda Accord moved forward. Based on the laws of physics, as the Honda was accelerated forward around and underneath her, Ms. Shillingford moved rearward relative to the vehicle's interior. During this motion, her lower back was supported by the padded seat back. The back of her head likely contacted the padded head restraint. After her initial rearward motion relative to the occupant compartment of her vehicle, Ms. Shillingford returned forward. The speed of her rebound motion would have been low, substantially less than the speed of her initial rearward motion, and would have returned her approximately to her initial position in the seat. Forward motion of her torso during this rebound would have been limited by interaction of her lap belt and shoulder harness restraint, which the police report and Ms. Shillingford's examination before trial testimony indicated she was wearing. Ms. Shillingford testified that her head contacted the steering wheel and that she lost consciousness. In her examination before trial, she also attributed breaking her front teeth to this impact with the steering wheel. In a low to moderate speed rear impact, such as in the subject

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accident, the rearward motion and the slower, limited forward rebound of a belted driver will not result in head-to-steering-wheel contact. Ms. Shillingford making head contact with the steering wheel and fracturing her teeth is inconsistent with the configuration of the subject collision and the corresponding physics of such an impact. It is noteworthy that the patient history taken down on different occasions in Ms. Shillingford's medical records indicates that there was no loss of consciousness in the subject incident and that her teeth were broken in a prior accident. It is also noteworthy that records of Ms. Shillingford's initial medical examination five days after the subject incident made no mention of fractured teeth. It is furthermore of note that a left side impact to the Honda Accord, as the CARFAX report indicated occurred on September 21, 2011, in a two-moving-vehicle collision would have resulted in the driver's head moving forward and leftward relative to the vehicle interior and possibly interacting with the steering wheel.

To understand occupant motion and loads experienced by the human body in low- to moderate-speed collisions, Exponent has performed crash testing using instrumented vehicles and instrumented anthropomorphic test devices (ATDs or crash test dummies) to determine the forces acting on occupants during vehicle-to-vehicle collisions involving vehicle delta-Vs similar to and greater than that of Ms. Shillingford's Honda Accord in the subject incident. The results of these experiments demonstrate that for belted occupants the loads acting on the cervical and lumbar spine during these impacts are substantially lower than the damage thresholds of the bones, ligaments, and discs of the lumbar spine, as reported in the biomechanical literature and provided no mechanism for spine movement beyond its physiological range of motion.

Low back analyses were also performed for Ms. Shillingford to compare the estimated loading on her lower back during the subject incident to lower back loads a female of her height and weight would experience during daily activities. The results of these analyses demonstrate that the loads Ms. Shillingford's lower back experienced in the subject collision were significantly less than the loads a woman of her height and weight experiences during typical daily activities such as bending over, carrying a 30-pound box, or lifting a garbage can, and were not substantially more than those present in a seated individual.

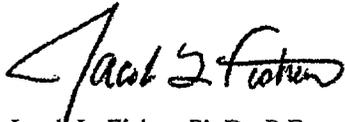
Cervical spine loads measured in these crash tests were additionally compared to those experienced in human activities such as vigorous activities or chiropractic treatment. These comparisons demonstrate that the cervical spine loads Ms. Shillingford experienced during the subject incident were similar to or less than those experienced by the cervical spine during vigorous non-contact activities, such as hopping, running with an abrupt stop, or vigorously shaking one's head. The loads her cervical spine experienced during the subject incident were also considerably less than those shown in biomechanical studies to be applied during chiropractic manipulation of the cervical spine.

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Ms. Shillingford's medical records indicate that she had intervertebral disc herniations at multiple levels of her cervical and lumbar spine. Biomechanical studies spanning half a century of scientific research have demonstrated that intervertebral disc herniations or bulges, without damage to adjacent bony structures, do not occur as a result of single episodes of force being applied to the spine in its normal range of motion. Ms. Shillingford's medical imaging records following the subject incident were read as unremarkable and indicated no acute bony damage to the cervical or lumbar spine. In the absence of damage to adjacent bony structures, intervertebral disc bulges and herniations have been produced experimentally only through repetitive application of force to the spine over thousands of cycles, through what is known in engineering terms as a fatigue process. This mechanism of intervertebral disc herniation without damage to adjacent bony structures is consistent with the repetitive forces Ms. Shillingford's spine experienced during daily activities and inconsistent with the single episode of minimal force her spine experienced in the subject incident.

Based on the biomechanical analysis presented above, within a reasonable degree of scientific and biomechanical engineering certainty, the subject incident provided no mechanism for causing Ms. Shillingford's cervical or lumbar intervertebral disc herniations. Furthermore, the subject collision also generated much less loading to Ms. Shillingford's lumbar spine than routine daily activities and generated no greater loading to her cervical spine than vigorous activity and less than that experienced during chiropractic manipulation. The opinions in this report are based upon the materials reviewed and the education, experience, and knowledge of the author, and are presented with a reasonable degree of biomechanical engineering and scientific certainty. If additional information becomes available, this report may be amended or altered.

Sincerely,



Jacob L. Fisher, Ph.D., P.E.  
Senior Managing Engineer