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ON-SITE CERTIFIED ADVANCED 208-COMPLIANT VEHICLE INVESTIGATION

CASE NUMBER - IN-04-035
LOCATION - Texas
VEHICLE - 2004 BMW 530I
CRASH DATE - September 2004

Submitted:

April 22, 2005
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Contract Number: DTNH22-01-C-07002

Prepared for:

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The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points be coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicle(s) or their safety systems.

Technical Report Documentation Page

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15. *Supplementary Notes* On-site air bag investigation involving a 2004 BMW 530i four-door sedan with manual safety belts and dual front advanced air bag system.			
16. *Abstract* This report covers an on-site investigation of an air bag deployment crash that involved a 2004 BMW 530i (case vehicle), which ran-off-road and impacted a curb and a utility pole. This crash is of special interest because the case vehicle was equipped with multiple Advanced Occupant Protection System (AOPS) features, including certified advanced 208-compliant air bags, which deployed as a result of the crash, and the case vehicle's restrained driver (60-year-old, female) sustained no injury, and the front right passenger (84-year-old, female) sustained only minor injuries as a result of the crash. The case vehicle was traveling northwest in the outside lane of a three lane undivided city street. The case vehicle's driver was trying to find her cellular telephone, and the case vehicle departed the right side of the roadway. The case vehicle entered the mouth of a driveway entrance to a parking lot, impacted a curb and the front of the case vehicle impacted a 15 centimeter (6.0 inches) diameter steel conduit pipe attached to a utility pole causing the case vehicle's driver and front right air bags to deploy. The driver stated that she did not take any avoidance actions. The driver was seated with her seat back upright, her seat track located between its middle and forward position and the tilt steering column was located between its center and full down positions. She was restrained by her three-point, lap-and-shoulder safety belt system, and the buckle-mounted pretensioner activated as a result of the crash. The driver was not injured and was not transported from the scene. The front right passenger was seated with her seat back upright and her seat track located in its full-rear position. She was restrained by her three-point, lap-and-shoulder safety belt system, and the buckle-mounted pretensioner activated as a result of the crash. The passenger sustained only minor interviewee reported injuries including a bruise across her chest and hips from the safety belt, and a cut between her right thumb and forefinger from the right front door grab-handle. She was not transported from the scene for treatment and sought no subsequent treatment for her injuries. Reconstruction determined a Delta V of approximately 30 km.p.h. (18.6 m.p.h.).			
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BACKGROUND

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This on-site investigation was brought to NHTSA's attention on or about October 21, 2004 by NASS CDS/GES sampling activities. This crash involved a 2004 BMW 530i (case vehicle), which ran off road and impacted a curb and a utility pole. The crash occurred in September, 2004, at 9:30 p.m., in Texas and was investigated by the applicable city police department. This crash is of special interest because the case vehicle was equipped with multiple Advanced Occupant Protection System (AOPS) features, including certified advanced 208 compliant air bags, and the case vehicle's driver [60-year-old, White (non-Hispanic) female] was not injured, and the front right passenger [84-year-old, White (non-Hispanic) female] sustained only minor injuries as a result of the crash. In addition, the manufacturer of the case vehicle has certified that it meets the advanced air bag requirements of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. This contractor inspected the case vehicle and scene on November 11, 2004 and interviewed the case vehicle's driver on November 24, 2004. This summary is based on the police crash report, scene and vehicle inspections, an interview with the case vehicle's driver, occupant kinematic principles and this contractor's evaluation of the evidence.

SUMMARY

The case vehicle was traveling northwest in the outside lane, and the driver was intending to continue traveling northwest. The case vehicle's driver was trying to find her cellular telephone, and the case vehicle departed the right side of the roadway. The right front and right rear wheels impacted a curb and the front of the vehicle then impacted a 15 centimeter (6.0 inches) diameter steel conduit pipe attached to a utility pole causing the case vehicle's driver and front right passenger air bags to deploy. The case vehicle rotated counterclockwise a few degrees and came to final rest against the utility pole facing northwest.

Based on the vehicle inspection, the CDCs for the case vehicle were determined to be: **12-FRWN-3** (**0**-degrees) and **12-FRWN-9** (**0** degrees) for the right front and right rear wheel impacts to the curb and **12-FCEN-2** (**0** degrees) for the utility pole impact.

The WinSMASH reconstruction program, barrier algorithm, was used to reconstruct the case vehicle's Delta V for the utility pole impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 30 km.p.h. (18.6 m.p.h.), -30.0 km.p.h. (18.6 m.p.h.), and 0.0 km.p.h. (0.0 m.p.h.). The case vehicle was towed due to damage.

Immediately prior to the crash the case vehicle's driver [60-year-old, White (non-Hispanic) female; 155 centimeters and 52 kilograms (61 inches, 115 pounds)] was leaning to the right looking for her cellular telephone. She had her left hand on the steering wheel and was using her right hand to search for the cellular telephone. The driver's left foot was on the floor and her right foot was on the accelerator pedal. The driver's seat track was located between its forward-most and middle position, her seat back was upright, and the tilt steering column was between its center and full-down positions. The driver was restrained by her three-point, lap and shoulder, safety belt, and the evidence indicated that she was most likely using the safety belt system.

The case vehicle's driver took no actions to avoid the crash. The case vehicle's impacts with the curb caused the driver to move forward and down into her seat just prior to the utility pole impact. The curb impacts most likely locked the passenger's seat belt retractor, and she most likely loaded her seat belt to some degree. The impact with the utility pole caused the driver to move forward along a path opposite the case vehicle's 0 degree direction of principal force as the case vehicle decelerated. The driver's buckle mounted pretensioner activated and she loaded her safety belt, and her face contacted the right central portion of her deployed air bag. The driver then rebounded back into her seat. The driver remained in her seat following the impact and was able to exit the vehicle without assistance. The driver was not injured and sought no treatment subsequent to the crash.

Immediately prior to the crash the case vehicle's front right passenger [84-year-old, White (non-Hispanic) female; 145 centimeters and 58 kilograms (57 inches, 128 pounds)] was sitting in an upright posture with both feet on the floor, her left hand on her lap, and her right hand grasping the right front door grab-handle. Her seat track was located in its full-rear position, and her seat back was upright. The passenger was restrained by her three-point, lap-and-shoulder, safety belt system. The passenger was wearing glasses at the time of the crash.

Just prior to the utility pole impact ,the case vehicle impacted a curb, which most likely caused the front right passenger to move forward and down into her seat. The curb impacts most likely locked the passenger's seat belt retractor, and she probably loaded her seat belt to some degree. The impact with the utility pole then caused the passenger to move forward along a path opposite the case vehicle's 0 degree direction of principal force as the case vehicle decelerated. The buckle-mounted pretensioner activated and the passenger loaded her safety belt causing an approximate 2.5 centimeter (1.0 inch) wide bruise across her chest, and a 25.4 to 30 centimeter (10 to 11 inch) bruise across her hips. She also sustained a cut between the right thumb and forefinger, which appears to have occurred as the passenger was gripping the right front door grab-handle, probably bracing for the impact. This cut was also the source of the blood smears observed on the front right air bag. As the passenger moved forward loading her safety belt, her face and chest most likely contacted her deployed air bag. The passenger then rebounded back into her seat. The passenger remained in her seat following the impact, and was able to exit the vehicle without assistance. The passenger was not injured and sought no treatment subsequent to the crash.

CRASH CIRCUMSTANCES

Crash Environment: The trafficway on which the case vehicle was traveling was a three-lane, undivided, one-way service road for an interstate highway, traversing in a northwest direction. A two lane driveway entrance to a parking lot intersected the north side of the trafficway forming a "Tee" intersection. The outside travel lane for the case vehicle's roadway was 4.7 meters (15.4 feet) wide, the center travel lane was 3.1 (10.2 feet) meters wide and the inside travel lane was 3.2 meters (10.5 feet) wide. The inside and outside lanes were bordered by mountable curbs, and there was a line of utility poles located approximately 0.7 meters (2.3 feet) adjacent to the outside curb. Roadway pavement markings consisted of single broken white lane lines. The case vehicle's approach to the crash location was uncontrolled at the time of the crash and the speed

limit was 72 km.p.h. (45 m.p.h.). A pedestrian warning sign and light with a 48 km.p.h. (30 m.p.h.) speed limit sign was also present, but it was not in effect at the time of the crash. At the time of the crash the light condition was dark with street lights, the atmospheric condition was clear, and the roadway pavement was dry, level bituminous. Traffic density was light and the site of the crash was urban commercial. See the Crash Diagram at the end of this report.

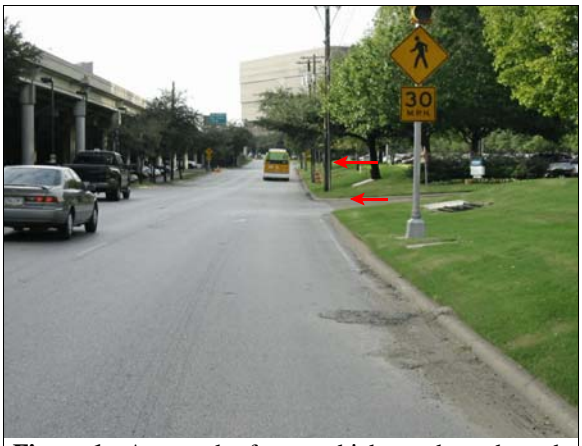


Figure 1: Approach of case vehicle northwestbound in outside lane, arrows show impacted curb and utility pole (case photo #01)

Pre-Crash: The case vehicle was traveling northwest in the outside lane (**Figure 1**), and the driver was intending to continue traveling northwest. The case vehicle's driver was leaning to her right looking for her cellular telephone and the case vehicle departed the right (i.e. north) side of the roadway and entered the mouth of a driveway to a parking lot. The driver stated that she did not take any avoidance actions. The crash occurred on the north side of the roadway.

Figure 2: Arrow shows damage to case vehicle's right front wheel from curb impact (case photo #19)

Figure 3: Arrow shows damage to vehicle's right rear wheel from curb impact (case photo #16)

Crash: As the case vehicle traveled to its right while the driver was looking for her cellular telephone, the right front and right rear wheels (**Figures 2** and **3**) impacted a curb on the northwest side of the driveway. The case vehicle traveled over the curb and the front (**Figure 4**) immediately impacted a 15 centimeters (6.0 inches) diameter steel conduit pipe attached to a utility pole (**Figure 5** below) causing the case vehicle's driver and front right air bags to deploy

Figure 4: Overview of damage to front of case vehicle (case photo #07)

and their buckle-mounted safety belt prestensioners to activate.

Post-Crash: The case vehicle rotated counterclockwise a few degrees and came to final rest against the utility pole facing northwest. The police crash schematic showed the case vehicle completely off the roadway at final rest.

Figure 5: The utility pole [each stripe on rod is 5 cm (2 in)], case vehicle impacted steel conduit pipe (case photo #04)

CASE VEHICLE

The 2004 BMW 530i was a rear wheel drive, four-door sedan (VIN: WBANA735X4B------) equipped with four wheel, anti-lock brakes; dual stage driver and front right passenger air bags, front door-mounted side impact air bags, front and rear side curtain "Head Protection System" air bags; driver and front right passenger, three point, lap and shoulder safety belts with seat belt buckle switch sensors, seat belt buckle mounted pretensioners, load limiting retractors, a front right seat occupant sensor and three point, lap and shoulder, safety belts in all three back seat positions. In addition, the manufacturer of the case vehicle has certified that it meets the advanced air bag requirements of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The various sensors in the case vehicle's advanced occupant restraint system analyze a combination of factors including the predicted crash severity and presence of a front right seat occupant to determine the front air bag inflation level appropriate for the severity of the crash.

CASE VEHICLE DAMAGE

Exterior Damage: The case vehicle's impact with the curb involved the right front and right rear wheels. The right front wheel sustained a small dent in the rim (**Figure 2** above). The right rear wheel sustained a dented rim, and the inner tire carcass was damaged causing an air bubble in the outer tire sidewall (**Figure 3** above). It is not known if the left front wheel was damaged. It had been removed from the case vehicle and was not available for inspection. The case vehicle's impact with the utility pole/steel conduit pipe involved the front bumper, grille and hood. The direct damage on the hood began 10 centimeters (4.0 inches) left of the centerline of the vehicle and extended 25 centimeters (9.8 inches) along the hood and approximated the shape of the steel conduit pipe (**Figure 6**). Crush measurements were not taken because most of the damaged front components had been removed. The left side wheelbase was shortened 15 centimeters (5.9 inches)

Figure 6: Top view of damage to case vehicle's front end (case photo #21)

while the right side wheelbase was extended 5.0 centimeters (2.0 inches). Induced damage involved the front bumper, grille, hood, right fender and left fender.

The recommended tire size was: P225/50R17 and the case vehicle was equipped with tires of this size on the right front, right rear and left rear positions. The left front wheel was missing. The case vehicle's tire data are shown in the table below.

Tire	*Measured Pressure*		*Recommend Pressure*		*Tread Depth*		*Damage*	*Restricted*	*Deflated*
	kpa	psi	kpa	psi	milli-meters	32nd of an inch			
LF	Unk	Unk	248	36	Unk	Unk	Unknown, wheel missing	No	Unk
RF	0	0	248	36	7	9	Rim dented	No	Yes
LR	193	28	303	44	7	9	None	No	No
RR	193	28	303	44	8	10	Rim dented, bubble in outer sidewall	No	No

Vehicle Interior: Inspection of the case vehicle's interior revealed several possible makeup smudges on the deployed driver's air bag and several drops of blood on the deployed front right air bag and right front door. No other evidence of occupant contact to any interior surfaces or components was observed. In addition, there were no intrusions to the passenger compartment, and no compression of the energy absorbing steering column or deformation of the steering wheel rim was observed (**Figure 7**).

Figure 7: Steering wheel and steering column showing lack of deformation (case photo #27)

Damage Classification: Based on the vehicle inspection, the CDCs for the case vehicle were determined to be: **12-FRWN-3** (**0**-degrees) and **12-FRWN-9** (**0** degrees) for the right front and right rear wheel impacts to the curb and **12-FCEN-2** (**0** degrees) for the utility pole impact.

The WinSMASH reconstruction program, barrier algorithm, was used to reconstruct the case vehicle's Delta V for the utility pole impact. Initially a CDC-only run was made. Then the estimated crush values were adjusted based on the case vehicle photographs until the WinSMASH graphics illustration of the crush profile appeared reasonable. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 30 km.p.h. (18.6 m.p.h.), -30.0 km.p.h. (18.6 m.p.h.), and 0.0 km.p.h. (0.0 m.p.h.). The case vehicle was towed due to damage.

The case vehicle was equipped with certified advanced 208-compliant frontal air bags at the driver and front right passenger positions. The driver and front right air bags both deployed as a result of the case vehicle's impact with the utility pole.

The case vehicle's driver air bag was located in the steering wheel hub. An inspection of the air bag module cover flaps and the air bag fabric revealed that the cover flaps opened at the designated tear points. There was no evidence of damage during the deployment to the air bag module cover flaps or the air bag. The air bag was designed with the front and back bonded together at the outer edge at the 12 o'clock, 3 o'clock, 6 o'clock and 9 o'clock positions. Each area contained three strips on bonding, each 9.0 centimeters (3.5 inches) in length and about 2.0 centimeters (0.8 inch) in width (**Figure 8**). These areas appeared to be designed to separate during deployment, and may be related to the dual stage deployment design of the air bag, or possibly related to controlling the shape of the air bag during deployment. There was no separation of the bonding at the 9 o'clock position, and only two of the three bonding strips separated at the 6 o'clock position. There was total separation of the bonding strips at the 12 o'clock and 3 o'clock positions.

Figure 8: Close view of the bonding strips on the driver's air bag (case photo #31b)

Figure 9: Driver's air bag, yellow tape shows area of probable makeup smears (case photo #28)

Figure 10: Driver's air bag vent ports (case photo #39)

The deployed driver's air bag (**Figure 9** above) was round with a diameter of about 58 centimeters (22.3 inches). The air bag was

designed without tether straps and had two vent ports (**Figure 10** above), each approximately 3 centimeters (1.2 inches) in diameter, located at the 10 and 2 o'clock positions. The air bag module was designed with four irregularly shaped cover flaps (**Figure 11**) made of thick pliable vinyl. The lower flaps were longer than the top flaps, and the circular BMW emblem formed the center portion of the left lower flap. The distance between the mid-center of the driver's seat back, as positioned at the time of the vehicle inspection, and the front surface of the air bag's fabric at full excursion was 12 centimeters (4.7 inches). Inspection of the air bag material revealed trace evidence of several probable makeup smears on the right central portion of the air bag indicating the driver's face probably contacted her deployed air bag.

Figure 11: Driver's air bag module cover flaps (case photo #26)

Figure 12: Overview of location of front right passenger air bag in top of right instrument panel (case photo #48)

Figure 13: Front right passenger air bag, blood smears in right lower quadrant (case photo #32)

Figure 14: Front right air bag module cover flaps (case photo #37)

The front right passenger air bag was located in the top of the instrument panel (**Figure 12**). The deployed front right air bag (**Figure 13**) was about 43 centimeters (16.9 inches) in width and 64 centimeters in height (25.1 inches). The distance between the mid-center of the front right passenger's seat back, as positioned at the time of

the vehicle inspection, and the front surface of the air bag's fabric at full excursion was 12 centimeters (4.7 inches). The air bag was designed without tether straps and had two vent ports, each 3.5 centimeters in diameter, located at approximately the 9 o'clock and 3 o'clock positions. The air bag module was designed with two cover flaps (**Figure 14** above). The top flap was 27.5 centimeters (10.8 inches) in width and 7.0 centimeters (2.8 inches) in height. The bottom flap was 27.5 centimeters (10.8 inches) in width and 5.5 centimeters (2.2 inches) in height on the left and 3.5 centimeters (1.4 inches) in height on the right. It was slightly bent during deployment. Both flaps were constructed of vinyl with a soft foam backing. Inspection of the air bag material revealed no evidence of occupant contact marks on the air bag. However, several blood smears were present on the lower right quadrant of the air bag. They were most likely blood drops from the front right passenger's right hand laceration due to contact with the right front door grab-handle.

CASE VEHICLE DRIVER KINEMATICS

Immediately prior to the crash the case vehicle's driver [60-year-old, White (non-Hispanic) female; 155 centimeters and 52 kilograms (61 inches, 115 pounds)] was leaning to the right looking for her cellular telephone. She had her left hand on the steering wheel and was using her right hand to search for the cellular telephone. The driver's left foot was on the floor and her right foot was on the accelerator pedal. The driver's seat track was located between its forward-most and middle position, her seat back was upright and the tilt steering column was between its center and full-down position.

The case vehicle's driver was restrained by her three-point , lap and shoulder safety belt. The driver stated she was using the safety belt, and the evidence indicated that the belt was in use at the time of the crash. The driver's buckle-mounted pretensioner had activated in the crash compressing the seat belt buckle stalk cover (**Figure 15**); however, no load marks were observed on the driver's shoulder belt or D-ring.. The measurement from the pretensioner piston to the end of the piston cylinder was 2.5 centimeters (1.0 inch). The driver's statement that she was leaned to the right looking for her cellular telephone indicates she was out of position, and may have been at least partially out of the shoulder belt at the time of impact.

Figure 15: Arrow shows compression of driver's seat belt buckle stalk cover

The case vehicle's driver took no actions to avoid the crash. She was not aware of the impending crash due to her preoccupation of looking for her cellular telephone. The curb impacts most likely locked the passenger's seat

belt retractor, and she probably loaded her seat belt to some degree. The impact with the utility pole then caused the driver to move forward along a path opposite the case vehicle's 0 degree direction of principal force as the case vehicle decelerated. The driver's buckle-mounted pretensioner activated and she loaded her safety belt, and her face probably contacted the right central portion of her deployed air bag. The driver then rebounded back into her seat. The driver remained in her seat following the impact and was able to exit the vehicle without assistance.

CASE VEHICLE DRIVER INJURIES

The police crash report indicated the driver sustained no injury as a result of the crash, and no ambulance was called to the scene. The driver reported that she was not injured as a result of the crash, sought no follow-up treatment and lost no work days.

CASE VEHICLE FRONT RIGHT PASSENGER KINEMATICS

Immediately prior to the crash the case vehicle's front right passenger [84-year-old, White (non-Hispanic) female; 145 centimeters and 58 kilograms (57 inches, 128 pounds)] was sitting in an upright posture with both feet on the floor, her left hand on her lap, and her right hand grasping the right front door grab-handle. Her seat track was located in its full-rear position, and her seat back was upright. In addition, the passenger was wearing glasses at the time of the crash.

The front right passenger was using her three-point, lap and shoulder safety belt. The inspection of her seat belt assembly revealed load marks on the D-ring (**Figure 16**) and shoulder belt (**Figure 17**). In addition, the buckle-mounted pretensioner had activated and compressed the front right seat belt buckle stalk cover (**Figure 18** below). The measurement from the pretensioner piston to the end of the piston cylinder was 1.0 centimeter (0.4 inch).

Figure 16: Abrasions (arrow) from the shoulder belt on the front right D-ring (case photo #45)

Figure 17: Plastic transfer from D-ring on front right shoulder belt (case photo #42)

Just prior to the utility pole impact ,the case vehicle impacted a curb, which most likely caused the front right passenger to move forward and down into her seat. The curb impacts most likely locked the passenger's seat belt retractor, and she probably loaded her seat belt to some degree. The impact with the utility pole then caused the passenger to move forward along a path

opposite the case vehicle's 0 degree direction of principal force as the case vehicle decelerated. The buckle-mounted pretensioner activated and the passenger loaded her safety belt causing an approximate 2.5 centimeter (1.0 inch) wide bruise across her chest, and a 25.4 to 30 centimeter (10 to 11 inch) bruise across her hips. She also sustained a cut between the right thumb and forefinger, which appears to have occurred as the passenger was gripping the right front door grab-handle, probably bracing for the impact. Blood was observed on the right front door near the grab-handle (**Figure 19**). This cut was also the source of the blood smears observed on the front right air bag. As the passenger moved forward loading her safety belt, her face and chest most likely contacted her deployed air bag. The passenger then rebounded back into her seat. The passenger remained in her seat following the impact, and was able to exit the vehicle without assistance.

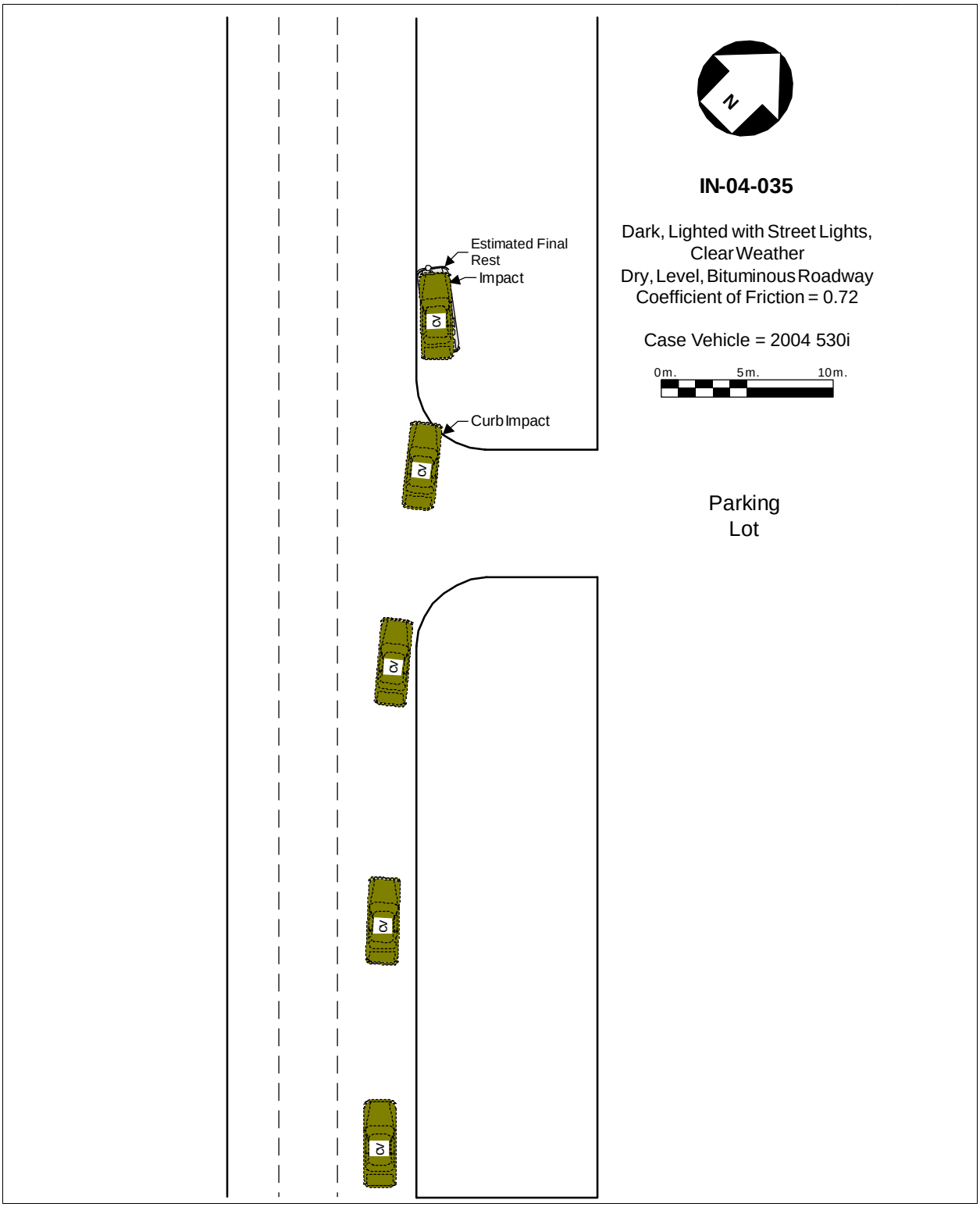
Figure 18: Compression of front right seat belt buckle stalk cover (case photo #48a)

Figure 19: Overview of blood drops on right front door, arrow shows grab-handle (case photo#50)

CASE VEHICLE FRONT RIGHT PASSENGER INJURIES

The police crash report indicated that the front right passenger sustained no injury as a result of the crash, and no ambulance was called to the scene. The driver-reported injuries to the front right passenger are presented in the table below. In addition, the driver (i.e., the passenger's daughter) reported that the passenger received no treatment for her injuries.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Contusion {bruise}, less than 2.5 cm (< 1 in), diagonally across chest, not further specified	minor 490402.1,4	Torso portion of safety belt system	Certain	Interviewee (driver)
2	Contusion {bruise}, 25-30 cm (10-12 in), across lower hips	minor 590402.1,8	Lap portion of safety belt system	Certain	Interviewee (driver)
3	Laceration {cut}, less than 2.5 cm (< 1 in), between right thumb and right forefinger (2nd digit)	minor 790602.1,1	Right side interior hardware and/or armrest (i.e., door grab-handle)	Probable	Interviewee (driver)


N
IN-04-035
Dark, Lighted with Street Lights,
Clear Weather
Dry, Level, Bituminous Roadway
Coefficient of Friction = 0.72
Case Vehicle = 2004 530i
0m.
5m.
10m.
Estimated Final
Rest
Impact
Curb Impact
CV
Parking
Lot