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March 19, 2015

The Honorable Gregory G. Nadeau
Acting Administrator
Federal Highway Administration
Southeast Federal Center Building
1200 New Jersey Ave. S.E.
Washington, DC 20590-9898

Dear Administrator Nadeau:

We are writing to put into the record our concerns about the conclusions expressed in *Inspection and Assessment of Crash Test Protocols: Task 3.1-Task 3.2 Report – Part II (31" ET-Plus System Crash Tests).* Our examination of the visual record and the methodology used to assess injury potential, in concert with the requirements of the NCHRP Report 350 lead us to a very different assessment of Test 31-30.

The most fundamental question the Federal Highway Administration must answer to ensure the safety of all roadway users is: Why are some ET-Plus energy-absorbing guardrail end terminals failing in the field causing serious injuries and deaths? To that end, crash tests can tell us: Does the device perform as intended in a controlled environment?

Regarding Test 31-30, the answer to the second question is: No, the ET-Plus did not perform as intended in this very controlled environment. After striking the guardrail end terminal, the W-beam becomes hung up in the chute as the vehicle begins to yaw. The rail ceases to extrude, allowing it to fold into a spear that is directed into the driver's side door, penetrating the occupant compartment of the test vehicle. This is the real-world failure scenario that has raised – and will continue to raise – controversy about the safety and efficacy of this device regardless of whether the subject test would have potentially caused serious injury to an occupant or not.

Instead of using the information conveyed by the test data to address the problem of ET-Plus energy-absorbing guardrail end terminals that fail in the field, the Federal Highway Administration gave the device a pass. However, in pursuit of this conclusion, the agency:

- Ignored the NCHRP Report 350 occupant risk criteria
- Failed to properly measure the intrusion
- Used the wrong set of crashes as a basis of comparison
- Confined its injury inquiry to the lower leg, even though the door directly struck the upper leg.
- Did not examine the potential for injury to the torso, head or arm

Ultimately, the agency has ignored the opinion of its own independent expert, who found:

"My conclusion is that the risk of serious injury cannot be discounted simply because the impact is to the legs. An AIS 3 femur fracture could occur as a result of an impact to the upper legs and would be considered a serious injury." [1]

Test 31-30 is clearly a FAIL.

**The Criteria Are Ignored**

Assessing "Occupant Risk," as defined in Table 5.1 of the NCHRP Report 350 test requires: "Detached elements, fragments, or other debris from the test article should not penetrate or show potential for penetrating the occupant compartment or present an undue hazard to other traffic, pedestrians, or personnel in a work zone. Deformations of, or intrusions into, the occupant compartment that could cause serious injuries should not be permitted."[2]

Further, NCHRP Report 350 Recommended Procedures for the Safety Performance Evaluation of Highway Features instructs:

> A factor listed in item D concerns deformations and intrusions into the occupant compartment. Of necessity, this factor must be assessed in large part by the judgment of the test agency and the user agency, or both. Risk of injury from a deformation depends on location, extent, and rate of deformation.[3]

It also states:

> Risk of occupant injury during impact with a highway safety feature depends to a large extent on the crashworthiness of the impacting vehicle. Crashworthiness depends in large part on the design of the occupant compartment including factors such as structural integrity, padding, restraint system, and so on. However, to the extent possible, the variability of vehicular crashworthiness has been removed from safety feature evaluation. Occupant risk is appraised according to gross vehicular accelerations because they are primarily functions of the safety feature design and the external structural design of the test vehicle. Whereas the highway engineer is ultimately concerned with safety of the vehicle's occupants, the occupant risk criteria of Table 5.1 should be considered as guidelines for generally acceptable dynamic performance.[4]

We note that these criteria were *not* followed.

First, Test 31-30 clearly showed penetration into the occupant compartment space – 6.75 static inches in the leg area, and much greater dynamic intrusion – there and elsewhere in the driver's occupant compartment. There was also evidence of penetration – yet, Dr. Clay Gabler avoids addressing the essential test criterion - which serves to protect vehicle occupants from failures like the one seen in this test. Instead of evaluating the potential penetration of the driver's door by the folded guardrail, he refers to the holes in the door, apparently caused by contact with guardrail, as "tearing" rather than penetration.

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[1]Inspection and Assessment of Crash Test Protocols: Task 3.1-Task 3.2 Report – Part II (31" ET-Plus System Crash Tests); Appendix A; Evaluation of the Potential for Serious Occupant Injury in SWRI Test ET31-30; Pg. 14; H. Clay Gabler; March 11, 2015

[2] NCHRP Report 350 Recommended Procedures for the Safety Performance Evaluation of Highway Features

[3] NCHRP Report 350 Recommended Procedures for the Safety Performance Evaluation of Highway Features

[4] NCHRP Report 350 Recommended Procedures for the Safety Performance Evaluation of Highway Features

Second, we question the judgment of the test agency. Dr. Gabler, the FHWA, and NHTSA ignore the effects of the maximum deformation. In other words, the testers and analyzers avoided the measure of dynamic intrusion.

The presence of real-world performance failures, accompanied by real-world severe injuries and data, obligates the FHWA to acknowledge that Test 31-30 demonstrates the potential for penetration of the occupant compartment and the deformation of the occupant compartment in a way that could cause serious injuries and deaths.  Based on these facts, a FAIL is required by the NCHRP Report 350.

**The Visual Record**

The video record shows that the ET-Plus energy-absorbing end terminal did not permit the rail to fully extrude, and allowed it to fold into a spear, causing at least 6.75 inches of post-crash intrusion into the vehicle. We note that the measurement was taken with the door *open*, which, of course, will result in a smaller intrusion measurement (see Figures 3.70 and 3.82 below).

**Figure 3.70: Post Test Vehicle – Left Side Door Panel** [5]


**Figure 3.81: Measuring Interior Deformation** [6]

Below, in the still image from the video at 5:09 minutes, the dynamic deformation of the door is shown pushing the steering wheel to the right, and it appears that door intrusion extends close to the centerline of the driver's seat.

[5] NCHRP Report 350 Test Report Compilation; SwRI ® Project No. 18.20887; Pg. 253; Southwest Research Institute; February 17, 2015

[6] NCHRP Report 350 Test Report Compilation; SwRI ® Project No. 18.20887; Pg. 253; Southwest Research Institute; February 17, 2015


Photographs of the deformed door shows the presence of holes in the exterior of the door, documenting *guardrail penetration* through the outside metal surface of the driver's door (Figure 3.67) [7]

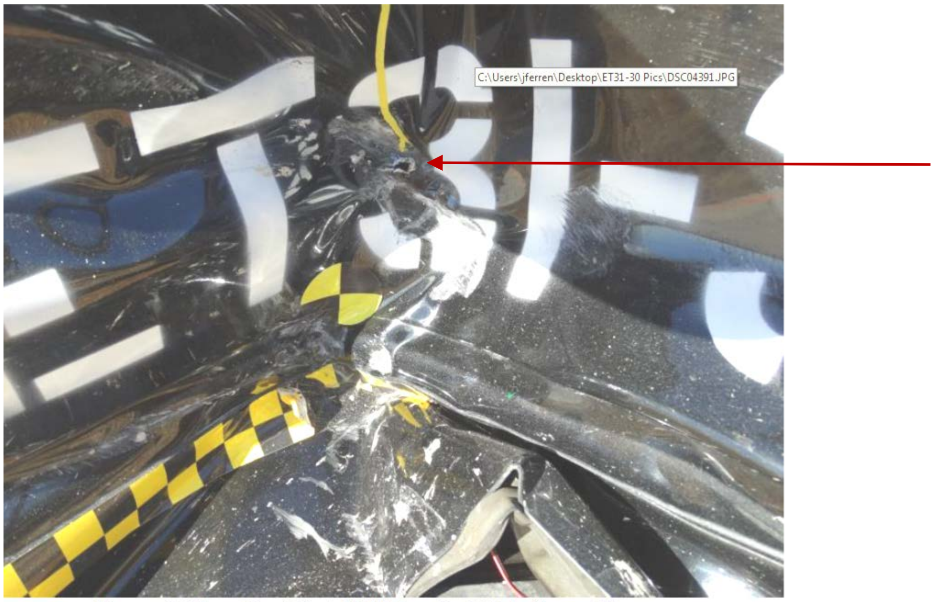


**Figure 3.67: Post Test Vehicle – Left Side Door, Close-up**

[7] NCHRP Report 350 Test Report Compilation; SwRI ® Project No. 18.20887; Pg. 253; Southwest Research Institute; February 17, 2015

There are also holes in the outboard side of the interior door panel that are potentially from intruding guardrail penetration or flying guardrail debris. (Figure 3.70). [8] These have corresponding holes/tears in the plastic in the inboard side of the door panel. (Figures 3.82; 3.83) [9] This is also in the area of the deformed seat pan and driver dummy's leg, which has tears in the pants cloth (Figure 3.72). [10]

**Figure 3.70: Post Test Vehicle – Left Side Door Panel**

**Figure 3.82: Location of Maximum Interior Deformation**

**Figure 3.83: Dummy Removed – Driver Side Occupant Compartment**

[8] NCHRP Report 350 Test Report Compilation; SwRI ® Project No. 18.20887; Pg. 253; Southwest Research Institute; February 17, 2015

[9] NCHRP Report 350 Test Report Compilation; SwRI ® Project No. 18.20887; Pg. 253; Southwest Research Institute; February 17, 2015

[10] NCHRP Report 350 Test Report Compilation; SwRI ® Project No. 18.20887; Pg. 253; Southwest Research Institute; February 17, 2015

**Figure 3.72: Post Test Vehicle – Left Side Door Panel , Interior**

The test video shows the dummy's left arm, torso and head flailing on impact. However, the FHWA's and Dr. Gabler's injury assessment is confined to injuries to the leg only. Injury potential to the left arm and torso, which interacted with the intruding door, and the head, which was pushed into the head restraint and into the area between the head restraint and b-pillar, should have been included in the evaluation.

**Dynamic Versus Static Intrusion**

To understand the true injury potential in dynamic crashes such as the 31-30 test, the best methodology would include testing with an instrumented dummy and analysis of the maximum, or dynamic, intrusion into the occupant compartment. Even though the FHWA took its analysis further than the test requirements, it only evaluated the post-crash intrusion amount.

During a motor vehicle impact, the impacted structure undergoes both plastic and elastic deformation. Plastic deformation returns the structure to a deformed state. Elastic deformation returns the structure to its original shape. In a vehicle crash, the impacted structure deforms, i.e. moves, a certain distance that encompasses both plastic and elastic deformation (dynamic deformation) and then the structure recoils to its final position which encompasses the plastic deformation (static or post-crash deformation).

The crash test video documents that the dynamic deformation in the test vehicle is significantly more than the static deformation. The extent of the dynamic deformation can be seen at times 5:09 and 5:57 in the test video (see still images below). It is clear that the dynamic deformation causes the interior door to intrude much further into the occupant compartment, even deforming the steering wheel, and then recoil to the post-crash deformation of 6.75 inches of intrusion. Dr. Gabler affirms this when he notes that the intrusion deforms the steering wheel. [11] [12]

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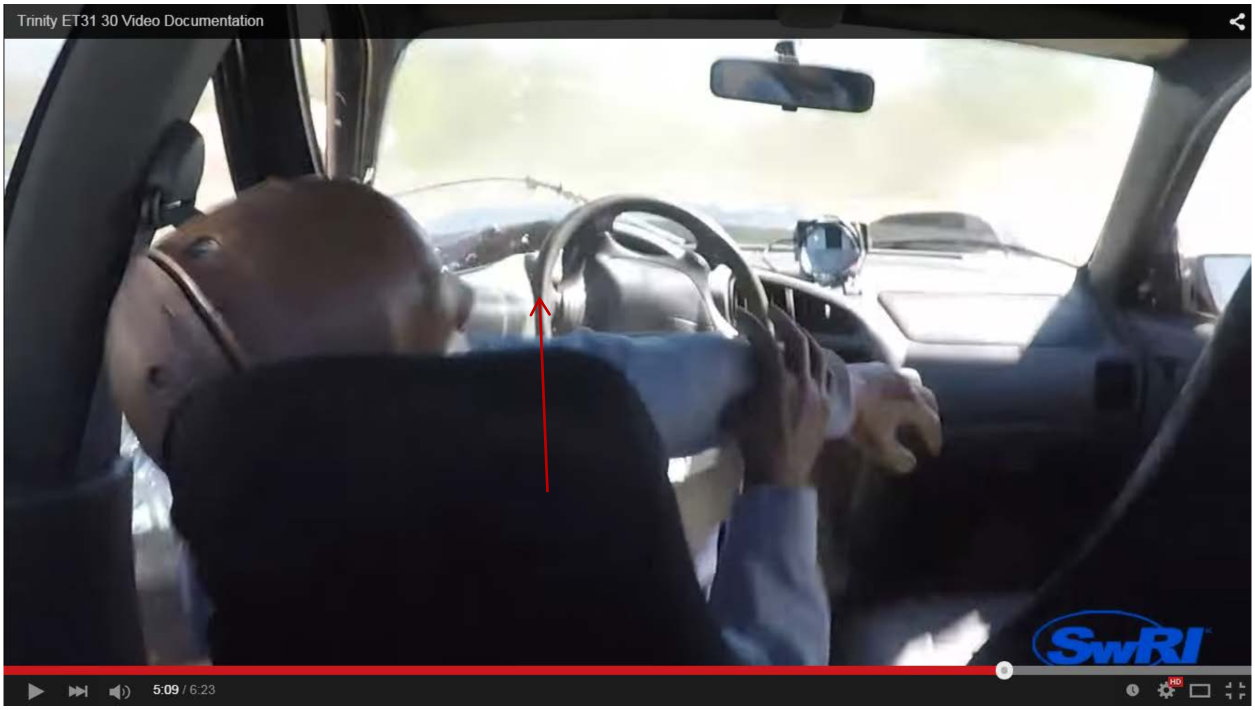
[11] NCHRP Report 350 Test Report Compilation; SwRI ® Project No. 18.20887; Pg. 253; Southwest Research Institute; February 17, 2015

[12] Inspection and Assessment of Crash Test Protocols: Task 3.1-Task 3.2 Report – Part II (31" ET-Plus System Crash Tests); Appendix A; Evaluation of the Potential for Serious Occupant Injury in SWRI Test ET31-30; Pg. 13; H. Clay Gabler; March 11, 2015





Because the FHWA did not instrument the dummy or measure dynamic intrusion, the agency and Dr. Gabler sought guidance on the injury potential from three different sources: the National Automotive Sampling System- Crashworthiness Data System (NASS-CDS), NHTSA deformable barrier side impact crash tests and the lower extremity injury evaluation criteria from the Insurance Institute for Highway Safety (IIHS). The use of data that did *not* exclude side impacts with wide deformation of the door, impacts from other vehicles, or even rollovers, and the use of NASS-CDS data that did not include the area of the body that experienced a direct door strike, render Dr. Gabler's conclusions invalid.

**NASS-CDS Analysis Flawed**

First, the National Highway Traffic Safety Administration's use of NASS-CDS data is flawed because it did not select the appropriate data that would provide a useful measure of the relationship between intrusion by a guardrail and serious injury potential. The crashes in the NASS-CDS database selected may include many non-comparable intrusion scenarios, such as rollovers and vehicle-to vehicle impacts, where the forces are distributed over a wider area.

As noted in Appendix B, NHTSA simply selected crashes in which the occupant was "seated in the driver seat in a passenger car or light truck. The highest or second highest deformation location had to be located on the left side of the vehicle and the specific location of damage needed to overlap the passenger compartment. The intrusion of interest had to be located at the driver's seating position and the intruding component was limited to the door panel. Additionally, the assigned injury source for the AIS 3+ lower leg injury had to be assigned to left panel or left interior."[13]

However, NASS-CDS data are coded for impacts with narrow objects such as guardrails, providing a much more relevant set of crash impacts for evaluation and comparison. For example, in 2013, Dr. Gabler was the co-author of a technical paper which examined 142 side impact crashes with guardrail end-terminals. As Dr. Gabler's paper demonstrates, limiting a NASS-CDS investigation to guardrail crashes changes the statistical picture for serious injury severity and risk. In *Injury Risk Posed by Side Impact of Nontracking Vehicles into Guardrails*, he states:

> Intrusion appears to be a major risk factor in guardrail-side crashes, particularly terminal crashes. Crashes directly involving the occupant compartment (SHL of passenger compartment) were far and away the most dangerous, accounting for only 3% of all nontracking guardrail-side crashes yet almost 40% of total injuries.[14]

And:

> For terminal-side crashes, driver-side impacts had significantly greater risk of injury compared with passenger-side impacts. Side crashes involving an end terminal were substantially over represented in driver injuries. End terminal contact occurred in about 25% of all guardrail-side crashes but represented almost 70% of driver injuries. [15]

Second, the FHWA's analysis of the NASS-CDS data is flawed because it focuses on the wrong body part. The agency extracted NASS-CDS crashes with driver's side door deformation at the same location as Test 31-30 "for case years 1997 through 2013 to document the relationship between door panel

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[13] Appendix B: National Highway Traffic Safety Administration's Deformation Evaluation; March 11, 2015

[14] Injury Risk Posed by Side Impact of Nontracking Vehicles into Guardrails; Nicholas S. Johnson and Hampton C. Gabler; *Transportation Research Record: Journal of the Transportation Research Board, No. 2377*, Transportation Research Board of the National Academies; 2013

[15] Injury Risk Posed by Side Impact of Nontracking Vehicles into Guardrails; Nicholas S. Johnson and Hampton C. Gabler; *Transportation Research Record: Journal of the Transportation Research Board, No. 2377*, Transportation Research Board of the National Academies; 2013

intrusion and lower leg injury."[16] Serious leg injury was defined as any below knee injury (not including the foot and ankle) of Abbreviated Injury Scale (AIS) 3 or greater. [17]

> Based on this, the FHWA concluded that for the range of door intrusions in side impact that result in to the 6.75 inches of intrusion, there would only be a 0.3% risk of serious lower leg injury in Test ET31-30. [18]

Dr. Gabler stated that "The impact of the folded rail with the door appeared to directly strike the distal end of the upper leg." [19] Nonetheless, in the NASS-CDS analysis, the agency did not assess the injury potential for the distal upper leg, the area of the body with the greatest potential for injury, caused by the area of maximum intrusion.

Simply put, the NASS CDS study only evaluates one body part, and the wrong one at that. And even if an analysis were to analyze the injury potential for all of the body regions that are vulnerable in this type of crash, an appropriate analysis should include critical statistical tests, evaluations of statistical significance, and confidence intervals.

**Deformable Barrier Tests Impacts not Comparable**

In attempting to assess injury potential of the dummy's lower extremity via NHTSA deformable barrier side impact crash tests and lower extremity injury evaluation criteria from IIHS tests, Dr. Gabler again mixes crash types with distinctly different loading scenarios.[20] The NHTSA deformable barrier side impact crash test encompasses broad distributed loading across the entire side of the occupant compartment rather than narrow/focal loading at the leading aspect of the driver's door as occurred in the 31-30 test.

Dr. Gabler determined that because the femur injury measures in Test 31-30 were below the IIHS injury thresholds in the NHTSA deformable barrier side impact tests with similar static intrusions, the deformation in Test 31-30 would not cause serious femur injury. Dr. Gabler concluded that "a driver exposed to the crash conditions of SwRI test ET 31-30 would have been unlikely to have been at risk of serious injury from the folded rail impact to the driver door." [21]

Again, this analysis is flawed because the loading to the femur is very different in Test 31-30 and the NHTSA test. In the NHTSA test, the 7.6" of intrusion is *distributed* along the occupant compartment whereas the 6.75" of intrusion in the 31-30 test is *centralized* at the distal end of the femur (just above the knee). The focal intrusion will result in much higher forces to the vehicle and the dummy than the broad distributed loading that occurs in the NHTSA deformable barrier side impact crash tests.

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[16] Appendix B: National Highway Traffic Safety Administration's Deformation Evaluation; March 11, 2015
[17] Appendix B: National Highway Traffic Safety Administration's Deformation Evaluation; March 11, 2015
[18] Appendix B: National Highway Traffic Safety Administration's Deformation Evaluation; March 11, 2015
[19] Inspection and Assessment of Crash Test Protocols: Task 3.1-Task 3.2 Report – Part II (31" ET-Plus System Crash Tests); Appendix A; Evaluation of the Potential for Serious Occupant Injury in SWRI Test ET31-30; Pg. 13; H. Clay Gabler; March 11, 2015
[20] Inspection and Assessment of Crash Test Protocols: Task 3.1-Task 3.2 Report – Part II (31" ET-Plus System Crash Tests); Appendix A; Evaluation of the Potential for Serious Occupant Injury in SWRI Test ET31-30; Pg. 13; H. Clay Gabler; March 11, 2015
[21] Inspection and Assessment of Crash Test Protocols: Task 3.1-Task 3.2 Report – Part II (31" ET-Plus System Crash Tests); Appendix A; Evaluation of the Potential for Serious Occupant Injury in SWRI Test ET31-30; Pg. 13; H. Clay Gabler; March 11, 2015

**Conclusion**

In sum, *Inspection and Assessment of Crash Test Protocols: Task 3.1-Task 3.2 Report – Part II (31" ET-Plus System Crash Tests)* goes to great lengths to justify a crash test failure as a PASS. But, in doing so, the FHWA has ignored its own test criteria, used incorrect crash types for comparative analysis and the selected the wrong data –NASS CDS crashes – to come to an injury determination for the wrong body part.

This is remarkable, given that the final test has provided the agency with rare insight – replicating an ET-Plus energy-absorbing end terminal failure that has occurred numerous times in real-world injury and death scenarios. The FHWA should be using that critical test as an opportunity to revamp the NCHRP Report 350 requirements to actually test for occupant injury risk. Test 31-30 should also serve as the foundation for answering the most important question: Why are some ET-Plus energy-absorbing guardrail end terminals failing in the field causing serious injuries and deaths?

Flawed science aside, Dr. Gabler's own analysis documented that this test should be a FAIL rather than a PASS because of the risk of serious leg injury: "My conclusion is that the risk of serious injury cannot be discounted simply because the impact is to the legs. An AIS 3 femur fracture could occur as a result of an impact to the upper legs and would be considered a serious injury." [22]

Unfortunately, while the FHWA ducks the question, it risks the safety of the public.

Sincerely,

Sean E. Kane
Founder and President of Board of Directors

Jamie Schaefer-Wilson
Executive Director

Cc: Tony Furst, Associate Administrator for Safety, Federal Highway Administration
R. B. Kalmbach, Executive Director, Contracts, SwRI
Dr. H. Clay Gabler, Virginia Tech Transportation Institute
The Honorable Sen. Richard Blumenthal, United States Senate
The Honorable Sen. Cory Booker, United States Senate
The Honorable Sen. Edward J. Markey, United States Senate
The Honorable Sen. Mark Warner, United States Senate
The Honorable Sen. Sheldon Whitehouse, United States Senate
The Honorable Sen. Tim Kaine, United States Senate
John Cox, President of Executive Committee, American Association of State Highway and Transportation Officials

[22] Inspection and Assessment of Crash Test Protocols: Task 3.1-Task 3.2 Report – Part II (31" ET-Plus System Crash Tests); Appendix A; Evaluation of the Potential for Serious Occupant Injury in SWRI Test ET31-30; Pg. 14; H. Clay Gabler; March 11, 2015