

Trinity ET-PLUS Guardrail Terminals - Review of Real-Life Collision Performance Data

Posting Date: 11-Oct-2015

1. Introduction

The ET-PLUS guardrail terminal manufactured by Trinity Highway Products (THP) of Dallas, Texas has been the subject of considerable concern with respect to its safe performance on North American highways. Following a U.S. jury's verdict in the fall of 2014 that Trinity defrauded the U.S. government by making secret adjustments to the terminal's dimensions, the U.S. Federal Highway Administration (FHWA) began a process of re-testing the ET-Plus. The FHWA also publicized a request for data on the performance of the system in real-life collisions.



Figure 1: Vehicles that strike an ET-Plus terminal have been harpooned by the attached guardrail resulting in severe injuries and deaths.

Like many entities in the public domain, Gorski Consulting became aware of the controversies regarding the ET-Plus performance from the general news media in the summer of 2014. While little was known about the issues at that time Gorski Consulting began a process of surveying the various installations of the ET-Plus in the vicinity of London, Ontario. Various articles were uploaded to the Gorski Consulting website showing general dimensions and photos of the installations. Without much access to the details of the controversies, or to any actual collision data, evaluation was limited to making comments about some of the possible factors that might influence the system's collision performance.

Following the completion of a survey of ET-Plus installations Gorski Consulting also conducted an examination of NASS cases of the U.S. National Highway Traffic Safety Administration. Some useful information was obtained from that study however, overall, it was apparent that the NASS files suffered from a lack of documentation of critical facts such as the damage to the impacted terminals, on-site photographs of the impacting vehicles' rest positions and the injuries sustained by the vehicle occupants.

In the spring of 2015 Gorski Consulting also uploaded an article to its website discussing some instances of collision-damaged ET-Plus terminals. This provided further information about how these systems might perform in real-life collisions. It was obvious however that, despite those efforts, key information about the ET-Plus performance was missing. Without any authority to conduct these investigations Gorski Consulting was unable to attend at the sites of these collisions when the vehicles were present nor could the vehicles be examined, or even photographed.

When a significant collision occurs the roadway is closed and no one from the public is allowed close enough to the vicinity, even to take basic photographs. This demonstrates the closed nature of the activities of official entities such as police and road maintenance personnel and the inability of the public to confirm whether those actions are being conducted in a manner that properly informs the public. The public is forced to accept that these official entities perform their tasks as they should. However there is little or no public, post-collision follow-up to confirm that belief. It will be noted later in this article that this belief is premature. Indeed there is evidence that essential components of official investigations into the functioning of important roadside devices such as the ET-Plus are lacking or non-existent, not only in the Province of Ontario but also in investigations carried out in the U.S.

In the Province of Ontario, much like the rest of Canada, the operations of those responsible for the installation and maintenance of roadside safety devices such as the ET-Plus are largely hidden. Few know the identity of these agencies and essentially nothing exists in resources such as the internet that would explain what these agencies do or how they do it. As imperfect as the U.S. federal government and its agencies may be, information about such activities in the U.S. has been found to be exponentially greater and better than in Canada. Thus essentially all of the information and discussion about the ET-Plus functioning in Ontario and Canada is taken from documents and studies from the U.S.

2. Description of the ET-Plus System and its Functioning

The ET-PLUS is a piece of roadside hardware that is attached to the end of a guardrail and is meant to reduce the injury consequences to occupants if a vehicle strikes it (See Figures 2 and 3).



Figure 2: View of a typical ET-PLUS guardrail terminal located on the eastbound exit ramp from Highway 401 to Highbury Avenue in London, Ontario.



Figure 3: Side view the ET-PLUS guardrail terminal showing the plate (head) on the right and the channel attached behind it. The end of the guardrail fits within the channel.

The terminal has a large plate (head) which is meant to be struck by a vehicle. A channel behind the plate is used as a guide within which the end the guardrail is designed to fit. The impact of the plate causes it to be displaced so that the plate and channel ride along the guardrail. This is accomplished because the guardrail slides within the channel and is squeezed into a narrow opening within the head. This squeezing causes the guardrail to become flattened and then is extruded out the side of the head. It is this motion, along with the flattening of the guardrail, that results in the dissipation of the kinetic energy that is introduced into the system as a result of the vehicle impact. Such dissipation of kinetic energy is a desirable action because it should lead to a controlled deceleration of the impacting vehicle and consequent reduction of injury to the vehicle occupants.

Figures 4 and 5 show an example of an ET-PLUS terminal on Dingman Drive in London, Ontario that was struck and sustained minor damage. Figure 4 shows a top view where the end of the flattened guardrail can be seen extruding from the side of the terminal head. Figure 5 shows the same terminal from a ditch-side view and we can also see a small portion of the guardrail as it has passed through the head and become flattened and curled by its squeezing action.



Figure 4: Top view of the ET-PLUS terminal showing how a minor impact has caused the head and channel to be displaced along the guardrail. Consequently the end of the guardrail has been squeezed out the side of the head.



Figure 5: Ditch-side view of the end of the guardrail as it has been squeezed and deformed from passing through the narrow opening in the head.

The functioning of the ET-PLUS has been criticized because of reports that the guardrail becomes jammed within the channel and head rather than passing through in the manner in which it was designed. The primary source of this criticism came from a competitor to Trinity, Joshua Harmon, who conducted a variety of investigations into the design changes of the ET-Plus and alleged reduced safety performance in real-life collisions. As explained by Harmon, the predecessor of the ET-PLUS, the ET-2000, contained a larger channel/head opening which, on face value, would be expected to allow the guardrail to pass through with less chance of jamming. The smaller opening of the ET-Plus caused it to jam or "throat lock". These allegations were supported by research in a University of Alabama in Birmingham (UAB) study which claimed that the ET-Plus had a poorer performance record in real-life impacts than the older ET-2000. This finding was also accompanied by revelations from Harmon that Trinity Highway Products (THP) had made these adjustments to the ET-Plus without informing the U.S. Federal Highway Administration (FHWA), like it was required. This resulted in a law suit against THP in which a federal jury found THP liable for defrauding the U.S. federal government. THP is now in the process of appealing that verdict.

In the interim, in late 2014, the FHWA took action by requiring that the ET-Plus be re-tested for compliance to the NCHRP-350 standard which determines whether it can be installed on roadsides in the U.S. The retesting took place in late 2014 and early 2015. The FHWA reported that the ET-Plus passed those re-tests and early comments by some news media gave the impression that the ET-Plus would appear to be of a safe design. However, a passing grade in several controlled tests, under ideal conditions, cannot be used to determine how the apparatus will perform in the real world, under less than ideal conditions. The real-life collisions need to be examined and this is what is referred to as the "in-service performance" of the ET-Plus terminal. The lack of this in-service evaluation is the focus of this article's content.

3. Federal Highway Administration Request For ET-Plus In-Service Performance Data

If the FHWA followed the protocols of NCHRP-350 then it would have known that recommendations existed in that document with respect to monitoring the "in-service" performance of the ET-Plus. For example below are some excerpts from the NCHRP-350:

"It is recognized that vehicle crash tests are complex experiments and are difficult to replicate because of the imprecise control of test conditions and the sometimes random and unstable behaviour of dynamic crush and fracture mechanisms. Accordingly, care should be exercised in interpreting the results."

"In service evaluation is used in the final stage of development of new or extensively modified roadside safety features and has the purpose of appraising actual performance during a broad range of collision, environmental, operational, and maintenance situations for typical site and traffic conditions."

"If its in-service is acceptable, it may then be classified as operational (step 11) and fully implemented. However, monitoring of the in-service performance of the device should continue in this phase (step 12)."

"However, it is strongly recommended that step 12 never be omitted."

"...the safety performance of a highway feature cannot be measured by a series of crash tests only. Testing must be viewed as a necessary but not sufficient condition to qualify a feature for operational status."

"As discussed in Chapter 1, the evaluation process should not stop with successful completion of tests recommended herein. In-service evaluation of the feature is perhaps more important than crash test evaluation and should be pursued as recommended in Chapter 7."

"The following sections describe goals and suggested procedures for in-service evaluation. However, it is well understood that the random and extremely complex

nature of vehicular accidents coupled with the resource limitations of transportation agencies greatly restrict the extent to which these goals can be met and the procedures can be carried out. With few exceptions these studies will be clinical in nature; it will not be feasible to collect sufficient data to develop statistically valid findings."

"It is recognized that certain design details may be identified during the in-service evaluation that, if properly modified, might improve some aspect of the feature's performance. Such modifications must not be made before their effect on feature safety performance is carefully verified through vehicular crash testing or other appropriate means (see item 10 in Figure 1.1). Past research has shown that seemingly minor variations in design details can adversely affect the safety performance of a feature."

"Even after a new or extensively modified feature has successfully passed the in-service evaluation and has been accepted for general use, the operational performance of the feature should continue to be monitored to a lesser degree to enable any flaws or weakness to be corrected or controlled as soon as possible (see item 12 of Figure 1.1). Such weaknesses may be due to conditions that were not anticipated, such as vehicle design changes or different installation site conditions."

Thus, NCHRP-350 clearly spelt out the importance of in-service monitoring of devices such as the ET-Plus terminal. Not only was in-service monitoring required because the NCHRP-350 said so, but it was basic, common sense. Anyone who had even a moderate level of understanding and experience with roadside safety would have understood that the few tests performed according to the NCHRP-350 protocols were not representative of the real life exposure that living human beings would experience on the actual highway system. This fact was eventually acknowledged by the FHWA. Thus, whether the NCHRP-350 required it, or common sense and experience required it, the FHWA was obligated to perform the in-service monitoring of the ET-Plus terminal.

For a time, Gorski Consulting believed that the FHWA had some form of monitoring system in place. After all, this was the Federal agency responsible for directing all the 50 States in the U.S. with respect to what devices they should install on the entire highway system of the U.S. and, indirectly Canada. Surely this federal agency would not make these directives solely on the basis of a few controlled tests in unrealistic scenarios. And there was no indication from the FHWA, or from any other agency to the contrary. Yet, no such data had ever been revealed, nor had the FHWA demonstrated that such evaluations were ongoing in the years that the ET-PLUS was being installed on North American highways. The only publicly available study is what was reported by the UAB researchers, noted above.

It was only after Trinity Highway Products was found guilty of defrauding the U.S. government that the FHWA administration took action. It announced that the ET-Plus would be retested. Secondly the FHWA indicated that it would examine the in-service collision data regarding the performance of the ET-Plus. Again, research of news media articles has not uncovered any indication that representatives of the FHWA were specifically asked by anyone what the FHWA had been doing in the past 10 years, and the FHWA also did not reveal what its actions were in the past 10 years, in terms of monitoring the in-service performance of the ET-Plus. Instead of following that direct

path of inquiry the news media provided the promotional avenue by which the FHWA was portrayed as commencing a new initiative of reviewing the data regarding the ET-Plus in-service performance.

Documents on the FHWA website confirm that the agency sent out a request for collision data on December 24, 2014:

"Another key component of FHWA's ongoing efforts is to evaluate the in-service performance of the ET-Plus. We are collecting a broad array of data to support this assessment. The FHWA asked all State DOTs to send us information regarding the performance of the ET-Plus on their roadways. Additionally, we have obtained information about the ET-Plus that was presented in the recent trial in Texas, as well as data received from parties involved in the trial. We have analyzed our own safety data and data from our Federal safety partners, including the Motor Vehicle Crash Causation Study, the Highway Safety Information System, and the Fatality Analysis Reporting System. We will objectively and thoroughly assess all of this information to reach a data-driven conclusion about the real-world performance of the ET-Plus."

The FHWA website indicated that a Task Force was created made up of members of FHWA as well as of the American Association of State Highway and Transportation Officials (AASHTO) to review the collision data and provide a report of their findings. Note that the ASSHTO is an umbrella organization which represents the 50 states in the U.S. In a sense, ASSHTO was asking itself for the data that it should have had.

On their website the FHWA indicated what collision data they received as a result of the above notice. The following is a list of those sources:

1. From the National Motor Vehicle Crash Causation Survey (NMVCCS) they reported reception of 78 cases. In fact, these cases appear to be investigations that were performed by the NHTSA NASS program and not a new and independent set of investigations.
2. From Joshua Harmon they received 231 cases. Many of these were serious collisions with substantial photographic documentation, while some showed the damage to the ET-Plus from a collision.
3. In an initial submission from the State of Missouri they received 34 cases. In a second submission they received an additional 38 cases.
4. From NASS they received 56 cases.
5. From the State of Delaware they received a sparse table of 12 cases but no information was available about the individual cases.
6. From the State of Connecticut they received a table similar to that of Delaware however with a list of only 6 cases.
7. From Washington State they received 162 cases.

8. From the State of Massachusetts they received 560 cases.
9. From the Safety Institute they received 39 cases.
10. From "Media & Other Sources" they received 15 cases.
11. They also reported the reception of 20 cases from a variety of sources involving other than ET-Plus terminals such as SKT and FLEAT terminals.

Reviewing the sources of the collision data, of the 50 states, only 5 states provided data to the FHWA. Two of those 5, Delaware and Connecticut, provided information on only 12 and 6 incidents, but no details about the individual cases. Thus the vast majority of state-related data came from only three states: Missouri, Washington and Massachusetts. This result should be perplexing to any independent observer. Why was it that only 3 out of 50 states provided any meaningful data? This is a question that cannot go unanswered.

The FHWA website contained a document prepared by the Task Force entitled " Report from Joint ASSHTO-FHWA Task Force on Guardrail Terminal Crash Analysis". This report related to the Task Force's review of the above-mentioned collision data. The Conclusions and Recommendations portions of that report have been attached below, interspersed with Gorski Consulting's reply :

"Based on the analysis, the Task Force developed the following conclusions and recommendations to address the identified w-beam guardrail terminal performance limitations.

Conclusions

1. Guardrail Terminal Crash Test Impact Conditions and Field-installed Conditions - The review of guardrail terminal performance based upon the limited number of crashes confirms what is acknowledged in National Cooperative Highway Research Program (NCHRP) Report 350^[1] and the AASHTO Manual for Assessing Safety Hardware (MASH)^[2] – there are real-world impact conditions that vary widely from the crash test matrices as related to vehicle type and sizes, first point of vehicle impact, vehicle non-tracking, and vehicle speed. Also, there are different installation and maintenance practices in place that can affect safety performance. Within the roadside safety community, it is recognized that even with the "best" practice of terminal design, with the wide variety of traffic and field conditions and applications, there will be crashes that exceed the performance expectations for the terminals. In addition, roadside features such as ditches, curbing, uneven terrain, and steep slopes in the vicinity of the terminal factor into the ability to mitigate the severity of the outcome of a guardrail terminal crash event. These terrain features can contribute to an increased likelihood of rollover during or after the impact event.

Gorski Consulting Reply To Conclusion #1:

The issue that the Task Force has failed to address is that real life collisions have been documented where the impact conditions did not appear to have been so extreme to

"...exceed the performance expectations for the terminals..." to the extent that harpooning or rollover of a vehicle was unavoidable. The expected purpose of the Task Force was to address these specific instances where the ET-Plus appeared to fail to protect the occupants of a vehicle. Specifically, the revelations of Mr. Harmon and the verdict of a federal jury concluded that alterations to the ET-Plus made it unsafe. It should have been the responsibility and the reason for the existence of the Task Force to address these specific concerns. The fact that controlled tests do not mimic real life conditions is not a revelation but a known and understood fact that did not need repetition or a large body of experts for confirmation.

2. Performance Limitations – Performance limitations are factors in a real-world crash environment that can contribute to the unsuccessful performance of a roadside safety hardware device. As indicated in MASH, guardrail terminals "are generally developed and tested for selected idealized situations that are intended to encompass a large majority, but not all, of the possible in-service collisions." Satisfactory performance can typically be expected for collision conditions similar to the test conditions. However, the performance of these devices is dictated by physical laws, vehicle stability, vehicle crashworthiness, and the site conditions of these real-world crashes. The more the crash conditions differ from the test conditions, the more likely it becomes that performance will be outside of the desirable limits.

Through its analysis, the Task Force identified several performance limitations for all types of extruding w-beam guardrail terminals reviewed in this study. The limitations fall into two general categories: 1) impact conditions, and 2) installation conditions. For impact conditions, the primary performance limitations that were identified include: 1) side impacts, 2) head-on/shallow-angle corner impacts, and 3) head-on/shallow-angle high-energy impacts. For installation conditions, the performance limitations identified include: 1) hardware installation/maintenance/repair issues, 2) grading issues, and 3) placement that does not conform to accepted guidance and practice. These installation conditions can adversely affect the safety performance of these devices, but it is unknown to what extent, since terminals are crash tested under ideal, controlled conditions.

Gorski Consulting Reply To Conclusion #2:

The Task Force focuses on "performance limitations" as the reason why ET-Plus terminals appear to have failed to protect vehicle occupants in collisions. Yet they confirm that they have received limited data. A blanket statement of this type, without reference to specific examples of cases where the "performance limitations" were exceeded, contains no useful meaning and cannot be viewed as a well-founded conclusion.

3. NCHRP Report 350 Crash Test Criteria – NCHRP Report 350 crash test matrices do not specifically address the performance limitations the Task Force identified. It appears that side impacts, head-on/shallow-angle high-energy impacts, and head-on/shallow-angle corner impacts may lead to safety performance issues. However, the data analyzed did not allow for an assessment of how frequently these situations occur (i.e., they may be limited or they may

appear on a regular basis) in the field. The shallow angle impact test condition is addressed in the MASH crash test criteria, but side impacts and front corner impacts are not specifically addressed in MASH. This points to the need to conduct in-service performance evaluations on roadside safety hardware including guardrail terminals; these evaluations are critical to determine whether crash-tested hardware have performance limitations that are not detected by the testing process and should be used to amend the crash test criteria in subsequent updates.

Gorski Consulting Reply To Conclusion #3:

The understanding that there is a "...need to conduct in-service performance evaluations..." cannot be a new revelation that comes from the Task Force's review of the data they received. The understanding that in-service evaluation was needed was a fact that should have been known to the FHWA many years before. As indicated earlier in this article the NCHRP-350 specifically noted in a number of instances that in-service evaluation was essential. However there is no indication that the FHWA took any action to perform such in-service evaluations until after Trinity Highway Products was found guilty by a federal jury. The confirmation is needed from FHWA that indeed they did not perform those evaluations in the 10 years that hundreds of thousands of ET-Plus terminals were being installed across North American highways. The FHWA then needs to explain why these required evaluations were not conducted.

4. Crash Testing of Extruding W-beam Guardrail Terminals – The Task Force considered additional crash testing of all existing NCHRP 350-compliant extruding w-beam guardrail terminals but concluded that such testing would not be informative because the performance limitations identified for these terminals fall outside of the NCHRP 350 testing matrices.

Gorski Consulting Reply To Conclusion #4:

There was no need for the Task Force to bring the issue of additional testing to this discussion as clearly this is not the issue of concern. It is the lack of in-service evaluation that is the matter of concern.

Recommendations

The Task Force developed the following recommendations:

1. Fully Implement MASH Compliance for New Installations of Guardrail Terminals –

This action is related to the roadside safety community setting a date by which new installations of guardrail terminals should be consistent with the MASH crash test criteria. MASH testing incorporates changes in the crash matrix details that will be more discerning for guardrail terminals. More specifically, MASH addresses impacts that occur at shallow angles, which is an important element in two of the performance limitations identified in this report. Each successive version of crash testing guidelines is meant to encourage manufacturers to advance the state of the practice and to develop safety devices that work with a changing vehicle fleet under a wider range of conditions. Because of the extensive

development and testing required, it typically takes many years after roadside safety hardware guidelines are established for products meeting those guidelines to be widely available on the market. However, in the six years since MASH was published, there have not been a significant number of MASH-tested devices developed and brought to market. Therefore, in order to encourage the expanded development and installation of MASH-compliant devices, the Task Force supports the roadside safety design community to expeditiously transition to the MASH criteria for all new installations of guardrail terminals.

Gorski Consulting Reply To Recommendation #1:

While advancement to the MASH testing may be desirable this recommendation should not have been the focus of the Task Force's assignment. The assignment of the Task Force should have been to determine whether the ET-Plus was failing to protect occupants of striking vehicles and whether the design changes in the ET-Plus mentioned by Mr. Harmon unnecessarily exposed occupants to harm. If affirmative then there should have been a recommendation whether to maintain or remove the ET-Plus terminals from the highway system.

2. Conduct In-Service Performance Evaluations of Guardrail Terminals – The Task Force recommends that comprehensive in-service performance evaluations of guardrail terminals be conducted at the national and State levels. As previously highlighted in this report, the Task Force's assessment did not involve a complete in-service evaluation and concentrated on a limited group of mostly higher severity crashes, specifically focused on crashes with the ET-Plus terminal. The findings of this report should be considered by the National Academies' National Research Council (NRC) committee that is conducting a project entitled "In-Service Performance of Energy-Absorbing W-beam Guardrail End Treatments." The intent of the NRC committee is to conduct exploratory work to determine what data are available, in sufficient quantity and quality, to allow for meaningful in-service evaluation studies of guardrail terminals.

Gorski Consulting Reply To Recommendation #2:

The purpose of the Task Force's existence should not have been to recommend the obvious fact that in-service evaluation should be performed. That requirement should have been obvious to the FHWA as it was required in the NCHRP-350 and it should have been obvious from a common sense viewpoint. The purpose of the Task Force should have been to confirm this lack of evaluation, indicate why it occurred and indicate how that would be corrected.

3. Expand Documentation of Guardrail Crashes – The Task Force recommends that AASHTO and FHWA encourage public agencies to thoroughly document guardrail crashes in order to allow for conducting more comprehensive in-service evaluations. Photographic evidence of an impacted guardrail and damaged vehicle(s) involved in a crash is extremely valuable and not typically captured. In addition, the Task Force recommends that AASHTO and FHWA request that the National Highway Traffic Safety Administration (NHTSA) thoroughly document guardrail crashes in its Crash Investigation Sampling System which is

being phased in over the next two years as the replacement for the NASS CDS. Also, NCHRP project 17-43, "Long-Term Roadside Crash Data Collection Program," is providing an opportunity to improve data pertaining to roadside safety hardware that helps address this recommendation.

Gorski Consulting Reply To Recommendation #3:

The Task Force expresses a lack of understanding in its belief that the NASS, or the future CISS, is able to "...thoroughly document guardrail crashes..." through its operations. NASS investigators cannot attend to an accident site in such a short time as to enable them to document important issues such as the damage caused to a terminal and guardrail and matters such as the final rest positions of the vehicles. In many instances NASS investigators may not become aware of a collision that becomes the target of their investigation until days and sometimes even weeks after the collision occurs.

NASS investigations are based on the development of a stratified random, sample from the whole population of collisions occurring in the U.S. While the specifics of how NASS carried out its program may vary, the process would operate in a similar fashion as follows. Statisticians mapped out zones where NASS teams would be located based on where the sampling needed to take place. In each zone the NASS investigators would be assigned certain cities, towns, or rural districts from which they would document the occurrence of every collision, usually by entering a collision report number in the pages of a log book. For a specific police station NASS investigators were provided with instructions as to the sampling rate (every 25th, 50th, 100th collision, etc.) for collisions documented at that police station. Thus the log book would be pre-printed to highlight every 25th case for example. As collision report numbers are written into the log book it becomes filled until that 25th report is reached and this 25th report becomes the case that NASS investigators will examine. In order that the NASS investigations be representative of collisions across the U.S. it is vitally important that this strict regime of random sampling be adhered to.

The sampling rate may change depending on the stratum within which the sampling is taking place. So in the case of a large city where many collisions occur, the sampling rate might be set rather high, say at every 100th or 200th collision. And collisions occurring in less populated areas might be sampled at lower rates, say every 25th collision.

Similarly, sampling rates might change depending on the collision severity. So fatal collisions might be sampled at 100%, personal injury (PI) collisions might be sampled at every 50th collision and property damage (PD) collisions might be sampled at every 100th collision.

Another practical consideration is that NASS team members cannot be sitting at every police station every day. Sampling may be performed once a week for example whereby a NASS investigator might have a pre-planned route to visit a certain number

of police stations. At police stations where collisions are less frequent a NASS investigator might make a visit every two weeks, or perhaps even every month.

For these reasons, when NASS investigators eventually obtain a copy of the collision report from which they will conduct their investigation. The collision might be a day or two old if it is a fatal, a few days old if it is PI in a well populated area, or it could be several weeks old if it is a PD in a less populated rural area.

The practical problem is that impact damage to guardrails and terminals is often repaired very quickly, often within hours of the collision so that traffic can begin using the roadway as quickly as possible. Even if NASS investigators become aware of a collision within a day they will likely lose the opportunity to document that damage.

Thus the type of documentation that the Task Force requested would require NASS investigators to be on 24-hour notice, likely living at a NASS "station" much like fire fighters, and await notice of a collision in the similar amount of delay. This cannot be performed within the current resources available to NASS centres. In practice, if documentation is to be successful it must be accomplished by those who respond first to the accident site, which means the police or those that police are willing to invite onto the collision site while their investigation may be on-going. At present police close roadways to any outside entities until their investigation is completed.

4. Advance Noteworthy Safety Data and Roadside Hardware Inventory Practices – The Task Force recommends that the highway safety community and transportation agencies bring forward noteworthy practices for developing and maintaining roadside hardware inventory systems and also those that link crash data to the location and type of roadside safety devices. This linking is important and critical to obtain complete information for analyzing roadside crashes. FHWA has a noteworthy practices database established at the following web location where this information could be added in the future: (<http://rspcb.safety.fhwa.dot.gov/noteworthy/default.aspx>).

Gorski Consulting Reply To Recommendation #4:

Coordination and cooperation is greatly lacking and greatly needed amongst all 50 states and all its police forces, hospitals, etc. if useful procedures and data are expected to be developed. States and local police forces cannot operate as independent states unto themselves, as has historically been the observed case in matters requiring national uniformity. Without this change, the data that is collected is likely to be a large and expensive quagmire of "unknowns", which is statistically useless, but also even more harmful if it is used as the basis for future policy.

5. Conduct Research on Vehicle Corner Impacts with Guardrail Terminals – The Task Force recommends that AASHTO and FHWA conduct research to evaluate the performance of vehicle front corner impacts with guardrail terminals to gain a better understanding of these crashes and the circumstances and conditions associated with them. Greater knowledge of this crash type could potentially be used to update future crash testing criteria. As

summarized by this report, there were observed performance limitations with extruding w-beam guardrail terminals when the impact occurred at or near the vehicle corner in the headlight area.

Gorski Consulting Reply To Recommendation #5:

While this recommendation appears appropriate it is very late in the process. This recommendation should have been developed in the early years of the installation of the ET-Plus terminal. We emphasize that, the FHWA and this Task Force are failing to inform readers that the lack of monitoring of the in-service performance of the ET-Plus terminal was a large and significant omission on the part of the FHWA. Failure to admit to that fact reduces the impact of the Task Force's recommendations, even when those recommendations may be valid and well-reasoned.

6. Conduct Research on Vehicle Side Impacts with Guardrail Terminals - The Task Force recommends that AASHTO and FHWA conduct research to evaluate the performance of vehicle side impacts with guardrail terminals to gain a better understanding of these crashes and the circumstances and conditions associated with them. Greater knowledge of this crash type could potentially be used to update future crash testing criteria. As summarized by this report, there were observed performance limitations with extruding w-beam guardrail terminals when the impact occurred on the side of the vehicle. The opportunity for research should be explored with NHTSA to review vehicle standards relative to the strength of the sides of passenger vehicles and to determine if vehicle side impacts into terminals and other fixed objects can be better addressed.

Gorski Consulting Reply To Recommendation #6:

While this recommendation appears appropriate, it needs to be re-emphasized that it is very late in the process. This recommendation should have been made in the early years of installation of the ET-Plus terminal.

7. Promote Proper Placement, Installation, and Maintenance Practices – The Task Force recommends that appropriate placement, installation, and maintenance practices be shared with the roadside safety community as was recently done through FHWA's May 26, 2015 memorandum. FHWA provides training and technical assistance on these practices, and the Task Force recommends that highway agencies take advantage of these resources. In addition, the Task Force recommends that AASHTO, through its Technical Committee on Roadside Safety, include additional content regarding proper placement, installation, and maintenance of guardrail terminals in the next edition of AASHTO's Roadside Design Guide.

Gorski Consulting Reply To Recommendation #7:

While the recommendation to share its expertise with the "roadside safety community" regarding placement, installation and maintenance practices would appear to be, on face value, reasonable, it should not be the Task Force's objective to make this recommendation since it should have been a basic action that the FHWA should have

been involved in throughout the decades of its existence. However, the FHWA has expressed the position that it was not aware of basic matters under their jurisdiction such as the in-service performance of installations such as the ET-Plus. Based on its own confirmation, the FHWA did not educate itself on this issue until it received the rather ineffective and incomplete list of cases upon which they have reported their conclusions and recommendations. Given this lack of knowledge, it remains questionable what useful expertise the FHWA can provide.

8. Crash Testing of Extruding W-beam Guardrail Terminals – The Task Force does not recommend additional crash testing of existing NCHRP 350-compliant extruding w-beam guardrail terminals for two reasons. First, the performance limitations identified for these terminals fall outside of the NCHRP 350 testing matrices, nor is it expected that NCHRP 350 tested devices function under all real-world conditions beyond what is present in the crash test scenarios. Second, as discussed in recommendation #1, the Task Force recommends that the roadside design community move to full implementation of MASH for all new installations of guardrail terminals which will help address an element of some of these performance limitations. Therefore, additional NCHRP 350 crash testing of existing guardrail terminals would be irrelevant since all crash testing since January 2011 has been required under the MASH criteria."

Gorski Consulting Reply To Recommendation #8:

The Task Force confirms that testing under NCHRP-350 alone cannot determine whether a device such as the ET-Plus will function appropriately in real-life collisions. That obvious fact was recognized in the HCHRP-350 and was expressed so. In-service evaluation is essential to this process and it appears that the FHWA did not undertake such an evaluation for at least the 10 years that the ET-Plus was being installed on North American highways. The Task Force has failed to make this point despite the fact that this would be obvious to any independent party who has examined this issue.

4. Review of In-Service Performance Data Received by the FHWA

In summary, the FHWA reported reception of 1251 cases. In the Executive Summary of the Task Force's report it indicated"

"Out of the 1231 cases, 161 cases were selected for the Task Force's detailed review and analysis. These cases that comprised the focus of the review were viewed as the most likely to show potential performance limitations and represented a limited sample across five different guardrail terminals. The data in this assessment were skewed toward severe crashes involving ET terminals"

Upon first glance 1251 would appear to be a sizeable number of cases from which to draw conclusions about the ET-Plus collision performance. Yet, a closer look reveals otherwise. As an example Gorski Consulting examined the content of the 78 National Motor Vehicle Crash Causation Survey (NMVCCS) cases. The summary table

describing those cases contained a column entitled "Reviewed by Task Force?". It would be reasonable to believe that this column indicated whether the FHWA task force had reviewed that particular file. Only 14 of the 78 cases contained an affirmative "Yes" that indeed the case had been reviewed.

Next, the first three NMVCCS cases that were reviewed by the FHWA task force were examined in more detail. These cases were identified by a "Case ID" as indicated below:

Case # 2007075518369

Case #2005008586181

Case # 2005049137263

The photos from these cases have been attached below.

Case # 2007075518369





Case #2005008586181





Case # 2005049137263





An important fact in each of the above three cases is that there were on-site photographs that showed the vehicle and the damaged terminal. The availability of such evidence is very important. So it is understandable why the Task Force would examine these collisions. However, despite the Task Force's claim that the data they examined was "...skewed toward severe crashes involving ET terminals" that does not appear to be the case. Each of these three cases indicates minor impacts.

In the first case a car is stopped against the damaged terminal and there is moderate damage to both the terminal and the vehicle. A collision of this severity would be unlikely to lead to any significant injury regardless of what was struck.

Similarly in the second case we see a Jeep in night-time conditions that has rolled onto its side after striking the terminal. A single photo of the terminal shows how it has rotated almost 90 degrees. The extent of passage of the guardrail through the head can be determined by examining the location of the "tooth holes" in the rail that indicate where the anchorage bracket was located for the cable that leads to the base of the first anchor post. Even though we do not see the length of rail that passed through the head this photo indicates that the length was rather short, as would be expected in this low severity impact. The fact that the Jeep rolled over in this low severity impact should indicate that, a higher severity of impact and at a higher speed of such a vehicle, a significant post-impact rollover could occur which is undesirable. Yet the total energy dissipation the vehicle and guardrail/terminal is relatively low.

In the third case we observe an green pick-up truck that has struck the terminal at a location just in front of the right rear wheel well. A second, white pick-up truck has struck the rear of the green pick-up but this can be viewed as minimal in its relevance. Still we recognize the minor nature of the impact both in terms of the damage to the terminal and the damage to the impacting pick-up.

Thus all three cases from the NMVCCS indicate collisions of a minor severity. These cases can provide minimal information about problems in the ET-Plus that might exist when the device is struck at higher speed and with higher impact severities. It is questionable what the FHWA task force can learn from examining such low severity impacts in light of the fact that many of the severe injuries and deaths to vehicle occupants appear to occur at higher collision severities and speeds. Furthermore, the content of these cases contradict the Task Force's assertion that it examined "*severe crashes*".

Further in this assessment the first three NMVCCS cases that were not reviewed by the FHWA task force are explored. These cases are:

Case # 2005013507642

Case # 2007075153624

Case # 2005012696122

The photographs from these follow:

Case # 2005013507642





Case # 2007075153624







Case # 2005012696122











It can be observed that in the first two cases that were not reviewed, the collisions were of minor severity. In the first case involving the white car, the impacted terminal was not an ET-Plus therefore this could provide the reasoning why the FHWA task force did not review that case. The second case also did not provide good views of the terminal and therefore it cannot be determined if this was an ET-Plus.

In the third case however the photographs indicate that this was a significant event. The photographs show that a car came to rest upside down and there was substantial damage to it. A text summary of the collision noted that the vehicle travelled into the median of an interstate highway and that the left front of the vehicle "contacted a guardrail". The vehicle then rolled onto its roof and slid into the opposing lanes of traffic. It was then struck by two other vehicles travelling in the opposing lanes. A passenger seated in the centre of the second seat of the vehicle sustained fatal injuries. There were not photographs of the "guardrail" therefore it is not clear whether an actual guardrail terminal was struck. However, if the "guardrail" was actually an ET-Plus terminal then the FHWA task force should have viewed this as an undesirable outcome. The point is that, given the fatal result it should not have been difficult for the Task Force to track down the type of guardrail or terminal that was struck as information about fatal collisions should have been readily available from local agencies. It is not clear why the Task Force did not perform this simple inquiry of an incident that appeared to have an undesirable outcome.

This case brings up the broader criticism regarding the process by which the FHWA set out to obtain data for assessment by their Task Force. Rather than actively contacting individual states and police forces as claimed the only visible evidence is that they chose a passive manner of sending a "notice" to anyone who might be interested in submitting data. This is not the action that should be expected from an agency who is the primary federal leader in determining what roadside devices will be deemed acceptably safe. There is no other agency that can or does perform that role. If, upon making the request for the data the FHWA received no responses would that mean that their responsibilities would end? Surely that cannot be the case. As the federal body that instructed states what devices they should install on their highways it was the responsibility of the FHWA to be aware of what devices were safe and that must have included an active search for "in-service" data on a continuous basis.

The FHWA reported that 560 cases were received from the State of Massachusetts. These came in the form to two documents. When opening the first document it reveals its size of over 2300 pages. A quick review of the first 700 pages revealed that these were damage reports related to the repairs of (primarily) ET-Plus terminals as a result of impacts. However, Massachusetts reported that its inventory system has not been undated yet to separate those instances of impacts to an ET-2000 versus the ET-Plus, thus all the incidents were delivered in the document. The damage reports dated back to at least the year 2009. Many of these damage reports contained a single, poor-quality, photograph of the damaged terminal and guardrail as well as its repaired condition. Essentially none of the reviewed reports contained any photographs of the vehicles that struck the devices. Those photographs of the damaged devices whose content could be deciphered demonstrated a very large range of damage results, not only in terms of magnitude of dissipated energy but also in the extent to which the guardrail passed through the terminal and the extent of deformation to the guardrail not associated with interaction with the ET-Plus terminal. The best assessment of this damage is that it was chaotic.

The re-testing of ET-Plus in late 2014 and early 2015 showed that relatively large portions of the kinetic energy of the impacts was dissipated through long lengths of ribboned guardrail passing through the ET-Plus head. In contrast, the damage visible in the Massachusetts reports showed more energy dissipation from collapsing and buckling of the rail, even though many of these collisions appeared to be at impact speeds that were lower than the controlled re-tests.

The second document of Massachusetts data contained over 1200 pages. A brief review indicated that these were similar to what was presented in the first document.

Overall, the Massachusetts data appeared to be the most comprehensive in terms of giving an indication of the minimum number of terminal impacts in that state. It would appear that this state was the most responsive to the FHWA's request for data. The obvious drawback to the data was the lack of good quality photographs. What general photographs were available were often too dark, providing only a general idea of the shape of the damaged terminal and guardrail. The lack of any photographs of the

damaged vehicles made it difficult to determine the success or failure of the ET-Plus device in reducing injury and death rates.

This demonstrates the difference in data from federal agencies such as NHTSA whose responsibility lies in insuring that vehicle safety standards are met and the data from individual states who are interested in the condition of the highway system. These agencies might attend the same accident site yet they document only those factors related to their primary obligations. Yet, in order to understand how these systems perform in unison, it must be essential to insure that a sufficiently detailed investigation is completed so that decisions can be made about how to improve the highway, vehicles or both. At present this cannot be done efficiently when agencies have a narrow vision of their responsibilities.

An interesting revelation accompanying the Massachusetts data was an estimated number of installations of the ET-Plus 4" versus the 5" channel width. Although not all the districts reported their data, the incomplete data indicated that there were 1128 installations of the 4" channel versus 241 installations of the 5" channel.

The Safety Institute provided data on 39 cases of which the FHWA indicated that it only reviewed 10 of those cases. Generally, most of these cases involve significant impacts where vehicle occupants have been injured or killed. A number of the records contain court documents indicating that civil litigation has commenced against Trinity Highway Products (THP), the manufacturer of the ET-Plus terminal. The photographs indicate a number of these cases involve the penetration of the guardrail into the vehicle occupant space and this intrusion was the likely cause of the occupant injuries and death.

News media articles were part of the packet of data attached with these cases. In reading these articles it was a revelation of the extent to which information about what actually transpired with respect to the harpooning of vehicles was not provided. Descriptions of vehicles striking guardrails or box beams or other inaccurate descriptions failed to connect the incident to a possible malfunctioning ET-Plus terminal.

While the data from Mr. Harmon was officially noted as 231 cases, those "cases" files contained sub-directories within which there were numerous other cases. For example a sub-directory labelled "GPS Accidents" contained records about 90 additional sites. Another sub-directory labelled "Tennessee" contained another 44 records. Although it is not clear whether some of these records are part of the 231, it indicates that Harmon provided far more comprehensive data on this issue than almost all of the 50 states.

This raises an important issue since, in almost all jurisdictions in North America similar policies exist regarding who investigates collisions and how those investigations are carried out. When a serious or fatal collision occurs, police attend the collision site and often shut down the roadway so that an investigation can be carried out. In most instances the public is not able to be present at the collision site and in many cases the public cannot even be within eyesight of the developments during the police investigation. In those instances where a guardrail and terminal sustain damage the police will call the local roadway maintenance personnel who will make repairs to those

damaged items. Those repairs are conducted in "secret" since the public is unable to see the evidence before it has been altered. Thus a great responsibility is laid upon the police and road maintenance personnel to complete a thorough and independent documentation of the evidence. It is only the police and roadway maintenance personnel who have access to the evidence and it is only they who will determine what evidence will be documented.

It is glaring therefore, when the FHWA made a request for data pertaining to ET-Plus collisions, how the vast majority of states failed to provide data to the FHWA. It is further glaring how not a single police force provided any information about its own investigations of which they must be the prime, and often the only, investigating entity in most serious and fatal collisions. Where are the documentations of those state and police cases? Why has the FHWA failed to make this important fact a focus in their conclusions and recommendations?

5. Closing Comment

In conclusion, review of the collision data upon which the U.S. FHWA made its conclusions and recommendations regarding the Trinity Highway Products ET-Plus terminal, demonstrated that the data was of poor quality and insufficient. It indicated that independent persons and agencies such as Mr. Joshua Harmon and the Safety Institute were more efficient and diligent in documenting the performance of the ET-Plus terminal than the official agencies, such as police, states and the FHWA whose responsibility it is to perform those documentations. This process has demonstrated how the investigative process is broken down. Individual states and police appear to act as serfdoms who have demonstrated no desire to insure that the federal government receives a detailed accounting of the collisions in their regions and jurisdictions. The FHWA also has demonstrated a failure to collect the essential data that should have been collected and evaluated, while installations such as the ET-Plus continued to populate North American highways for over 10 years.

Even now the FHWA administration has failed to address the specific concerns of the safe functioning of the ET-Plus. Numerous concerns have been expressed in the news media, by government representatives and private individuals wanting to obtain clarification whether the ET-Plus terminal is a reasonably safe product or whether it should be removed from all North American highways. The FHWA must have known that these concerns existed when they made it known that the ET-Plus would be retested and that there would be a review of its in-service performance. Yet the result of the FHWA's inquiries has led to their conclusion that the controlled testing via the NCHRP-350 is insufficient. This is an obvious fact that should have been known before the re-testing.

The Task Force of FHWA and AASHTO representatives expressed a meandering set of conclusions and recommendations that did not focus on the specific issue of the safe

functioning of the ET-Plus in real-life collisions. Comments were made such as the one below:

"Within the roadside safety community, it is recognized that even with the "best" practice of terminal design, with the wide variety of traffic and field conditions and applications, there will be crashes that exceed the performance expectations for the terminals."

No one can dispute such broad generalizations. However comments such as these do not address the specific issue that the FHWA should have been addressing: the status of in-service performance of the ET-Plus terminal. As indicated by Mr. Jesse Harmon design changes were made to the ET-Plus and those changes allegedly caused the terminal to "throat lock" such that it caused unnecessary injuries and deaths. The purpose of the FHWA's inquiries should have been to determine whether those allegations were accurate. Did the condition of "throat lock" exist? Was it a function of the changed design of the ET-Plus. What specific cases did the FHWA examine that allowed them to confirm or deny those allegations? A preliminary examination of the 161 cases that were coded "Reviewed by Task Force" did not appear to contain the type of information that could lead the Task Force to conclude that a safety problem with the ET-Plus did not exist.

Gorski Consulting
London, Ontario, Canada

*Copyright © Gorski Consulting,
All rights reserved*