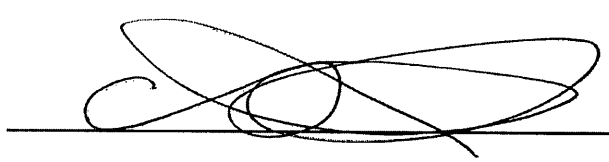
Comparative Analysis of Occupant Protection and Overall Passenger and Driver Safety Between Purpose-built Commercial Yellow Taxicabs and Standard Passenger Hybrid Yellow Taxicabs in New York City



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PROFESSIONAL CREDENTIALS:

The author is a licensed Professional Engineer in New York, Michigan, and Connecticut and has worked as an accident reconstruction expert full-time since 1982, serving as an expert court witness in 11 states. The author has a great deal of experience in auto safety as a result of his work. Clients have included the City of New York, Ford Motor Company, General Motors, NYC Transit Authority, the New York Attorney General's Office and numerous major insurance companies and private attorneys. The author has inspected more than 3,000 vehicles and performed more than 1,300 detailed accident reconstructions. A copy of the author's C.V. is attached as Appendix A.

PREMISE AND PURPOSE OF ANALYSIS:

New York City yellow taxicabs comprise what is arguably the most heavily worked fleet of vehicles in the world and present a unique set of engineering challenges for automakers and operators. New York City taxis often run 24 hours a day, 7 days a week (24/7) in all weather conditions, on all types of road surface, in heavy traffic and on the highway. They frequently transport multiple passengers with heavy luggage loads and travel short and long distances alike. Fleet taxis typically travel 85,000 to 100,000 miles a year. In recognition of this unique and rigorous vehicle use, the New York City Taxi and Limousine Commission (TLC) requires that all double-shifted taxis be retired every three years and replaced by new vehicles.

The Metropolitan Taxicab Board of Trade retained the author out of industry concern over the safety of hybrid taxicabs in light of a TLC mandate requiring that new taxicabs achieve a 25 mpg city EPA rating starting October 1, 2008 and a 30 mpg city EPA rating starting October 1, 2009. At the time this report was written, with the exception of a clean diesel Volkswagen Jetta which comprises 0.00% of all New York City taxicabs, only hybrids meet the

specifications of the 25/30 mandate. As far as the author is aware, he is the only professional engineer who has analyzed occupant safety in hybrid taxicabs.

The **purpose of this analysis** is to determine whether the newly mandated hybrid New York City Taxicabs are safe for passengers and drivers. To determine this, the author inspected and ran tests on:

(1) the current, conventional Ford Crown Victoria Long Wheel Base;

(2) three of the TLC currently-approved hybrid taxicabs: the Ford Escape Hybrid, the Nissan Altima Hybrid, and the Toyota Highlander Hybrid – all with TLC-approved L-shaped partitions; and

(3) a 2007 Ford Escape Hybrid taxi that had been totaled in a rear end collision.

For these vehicles, as well as for the Toyota Camry Hybrid and the Toyota Prius Hybrid, the author also analyzed past and current performance in 24/7 taxi service as well as publicly available safety information, including:

(1) the National Highway Traffic Safety Administration (NHTSA) crash test films and simulations;

(2) the NHSTA crash test star ratings;

(3) the Insurance Institute for Highway Safety's (IIHS) safety testing; and

(4) the warnings in these vehicles' owners manuals.

When inspecting these taxis and analyzing this publicly available safety information, the author sought to determine:

(1) whether NHTSA and IIHS safety ratings are a reliable source for approving vehicle models for use as NYC taxis;

(2) whether, in each of these vehicles, a backseat occupant's head will strike the TLC-mandated partition in a front-end collision;

(3) whether the L-shaped partition is particularly dangerous due to its sharp edges;

(4) what other safety problems, if any, the TLC-mandated partitions cause in the TLC-

mandated hybrids for both rear-seat and front-seat passengers;

(5) whether the hybrid SUVs have stability problems, and the significance of such problems under the rigorous conditions of NYC taxi use;

(6) whether the owners manuals of these vehicles prohibit alterations mandated by the TLC;

(7) what other problems, if any, the TLC-mandated hybrid taxis have; and

(8) what steps should be taken to ensure the safety of the NYC riding public.

SUMMARY OF ANALYSIS:

As discussed in detail in this report, the author found that the Ford Crown Victoria Long Wheel Base (LWB) is the safest taxicab available. This finding is not surprising as the Ford Crown Victoria has been operating for 25 years as a New York City taxicab and 6 years as a purpose-built LWB version that provides 6 additional inches of rear occupant space. It is also widely accepted that the Crown Victoria LWB "taxi package" is the safest and most durable taxicab on the road.

The Ford Crown Victoria LWB is the only TLC-approved car with across-the-board five-star safety ratings from NHTSA – an important rating, though only one of several metrics required to assess taxicab safety. The Crown Victoria is a big, heavy-duty commercial vehicle with a heavy-duty frame and heavy-duty parts. It is produced exclusively for the police and taxi markets. As purpose-built taxis, Crown Victorias are engineered to withstand serious collisions and 24/7 commercial usage. They also feature large crumple zones that reduce forces on occupants in crashes, appropriate space and structural components for required partitions, abundant rear and front occupant space, and sufficient luggage space. As a result, the Crown Victoria performs very well in crashes, even with a full width partition – a modification that requires adequate interior space to fully protect rear-seat occupants from impacts with the

partition.

As far as automotive safety is concerned, at least one thing has not changed in over a century. All things being equal, **larger and heavier vehicles are safer vehicles**. Larger vehicles absorb impacts more easily, feature larger crush zones and are the best equipped vehicles to protect occupants from injuries. Smaller and lighter vehicles are not as safe in collisions. They have less crush space and less mass to absorb the impact of an accident. **You cannot change the laws of physics.** To compensate for the engineering challenge of smaller vehicles, the automotive industry has created elaborate safety systems including side curtain air bags, adaptive occupant restraint systems and seatbelt pretensioners.

The hybrids – which were designed for private, non-commercial use and are significantly smaller than the Crown Victoria – are not nearly as safe as the Crown Victoria even without the modifications required by the TLC. All other things being equal in a crash, occupants in the lighter hybrids are more likely to suffer from injuries than occupants in the heavier Crown Victoria. The g-load (force or acceleration) that an individual would experience in a collision would be 40% greater in a Ford Escape Hybrid than it would be in a Crown Victoria LWB. A 40% reduction in the peak g-load during a crash is highly significant and will dramatically reduce the potential for injury.

Moreover, **the modifications required by the TLC render these hybrids <u>unsafe</u>**. To compensate for their small size, these hybrids are designed with side curtain airbags to protect occupants in collisions. It is the author's strong professional opinion that the TLC-mandated partition (whether L-shaped or full width) will interfere with the deployment of side curtain air bags. This seriously compromises the vehicle safety system, which is essential to determining the overall crashworthiness of the vehicle.

To the best of the author's knowledge, the TLC has never crash-tested the modified hybrid taxis it has mandated, nor has any entity, despite these fairly obvious safety concerns. Nor have the hybrids been tested as 24/7 taxicabs in any significant manner for any significant period of time on the road, even though the hybrids were built for the consumer market where the average mileage is less than one-fifth of that of a double-shifted New York City taxi. Furthermore, in an apparent violation of the TLC's own rule, none of the hybrid taxis that this author analyzed had anything close to the required six inches between the wall of the vehicle and the partition. This is not surprising considering that a gap of six inches would negate the entire purpose of a partition, which is to protect the driver from being assaulted, injured, robbed and killed. A gun or other weapon can easily be maneuvered into a six-inch gap.

Due to the mandatory vehicle modifications, the TLC has, in effect, created its own vehicle design. As such, the TLC has an obligation to crash-test the modified vehicles or require that the automakers crash-test the vehicles as modified. No automaker would put such an inadequately tested vehicle on the road, nor should the public or any federal regulatory agency stand for it. The TLC's lack of attention to safety and failure to protect drivers and passengers is simply astounding and would be considered gross negligence in the automotive industry.

The lack of adequate safety testing was vividly demonstrated in August 2008 when, in response to an advisory by manufacturers, the TLC issued a warning and directive, requiring all owners to remove vinyl seats/covers, which are mandated by current TLC specification rules, because they may interfere with the front-seat occupant classification system. This system measures the physical characteristics of the front-seat occupant and adjusts the SRS (air bag) and seat-belt system for the occupant's physical characteristics. Failure of this system to work properly could cause injury and possibly result in failure of the vehicle to meet government crash

test standards.

The TLC-mandated partition (whether L-shaped or full width) is an even more obvious impediment to side curtain air bag deployment. The L-shaped partition is particularly dangerous, due to its prominent hard surfaces and sharp edges – an anomaly in an automotive industry that strives specifically to avoid hard surfaces and sharp edges. It is the author's opinion that there are no safe seats for drivers and passengers in hybrids outfitted with an L-shaped partition, as every seat places its occupant in serious danger in front and side crashes. This crude modification changes the entire interior environment and takes us back about a half a century in automotive safety.

KEY FINDINGS:

NHTSA AND IIHS SAFETY RATINGS DO NOT PROVIDE A BASIS TO ASSERT THAT REAR SEAT OCCUPANTS ARE SAFE.

NHTSA and IIHS safety ratings are not an acceptable source for the TLC to rely upon because NHTSA and IIHS (a) do not conduct front or rear end crash tests on rear seated adult occupants – the vast majority of NYC taxi passengers; and (b) do not conduct tests on cars modified as required by the TLC. Indeed, it is completely unknown whether these modified cars would pass federal crash tests.

The federal government does not test rear occupant adult safety in front and rear crashes because of the dramatic differences in the occupant environment between the front seat and the rear seat. Front seat occupants must be protected from the dashboard, steering wheel, windshield and other hard surfaces. Rear seat occupants typically have a soft, benign, energy-absorbing seatback to cushion an impact. By adding the partition, however, that soft surface is turned into a hard elastic partition, which might as well be a steel wall.

MODIFYING HYBRID TAXIS WITH PARTITIONS WILL RESULT IN FREQUENT AND SEVERE FACIAL INJURIES DUE TO INADEQUATE SPACE BETWEEN THE PARTITION AND PASSENGER.

Due to the reduced distance in hybrids between the backseat and the TLC-mandated partition, even belted backseat passengers will be seriously injured during accidents in hybrid taxis because they will not have adequate space to allow for occupant excursion (movement) before the occupant's head collides with the hard, unyielding and elastic partition (whether L-shaped or full width). In contrast, belted passengers in Crown Victorias will not hit the partition because the distance between the backseat and the partition is approximately eight to ten inches greater than the distance available in the Ford Escape Hybrid and other small hybrids. **The significant difference in rear-seat occupant space between a Crown Victoria and a small**

hybrid vehicle like the Escape, Highlander and Altima is the difference between striking the partition and not striking the partition in an accident. This can readily have fatal consequences. Indeed, in 2001, the Crown Victoria was lengthened by six inches, in part, because doctors testified at TLC hearings that passengers were receiving severe facial injuries in minor crashes due to the close proximity of the partition to the rear-seat occupant.

THE TLC-MANDATED PARTITIONS INTERFERE WITH SIDE CURTAIN AIR BAG DEPLOYMENT AND CAUSE OTHER SERIOUS PROBLEMS.

The TLC-mandated partitions cause a number of other safety hazards, including: (a) in hybrids, the partitions (whether L-shaped or full width) obstruct the functioning of the side curtain airbags, which these vehicles need in order to compensate for their small size; (b) the sharp edges, corners, hard surfaces, and constricted design of the L-shaped partition increase the likelihood of injury and severe facial lacerations for all passengers including the driver; (c) the driver in a vehicle with an L-shaped partition faces a strong glare from the right side window and is particularly at risk of injury or death because of being forced to sit too close to the airbags, and may have extreme difficulty escaping in a crash due to the surrounding partition; and (d) while the Crown Victoria design permits easy and secure installation of the partition to a structural component – the B-pillars on each side of the vehicle – the L-shaped partition cannot be securely mounted and is likely to dislodge during crashes causing severe injury. Indeed, the L-shaped partition in the Ford Escape Hybrid taxicab the author inspected completely dislodged from its mounts and landed in the rear-seat area, compromising the leg space of the left rear-seat occupant.

SUVs, SUCH AS THE FORD ESCAPE HYBRID, ARE MORE LIKELY TO ROLL OVER CAUSING SERIOUS INJURY.

The Crown Victoria has a five-star stability or rollover resistance rating and maintains a

high four-star rating even when the vehicle is fully loaded (six passengers or 1100 pounds of load). In the author's 26 years as an accident reconstruction expert, he cannot recall a single case where the Crown Victoria or a similar vehicle has rolled over in a vehicle-to-vehicle crash.

For SUVs like the Ford Escape Hybrid, rollovers are not uncommon events. The Escape has only a three-star NHTSA rollover rating. When fully loaded, as taxicabs often are, the Escape's stability rating drops to a low two-star rating that is very close to a one-star rating. The risk of rollover is so severe in the Escape that the owners manual warns drivers not to make sharp turns and to be particularly careful when the SUV is fully loaded. Because sharp maneuvering and sharp turns are a daily fact of life for NYC taxicabs, the rollover tendency of the Escape is a potentially deadly flaw.

THE HYBRID MANUFACTURERS WARN AGAINST MODIFICATIONS LIKE MANY OF THOSE MANDATED BY THE TLC.

The owners manuals, if followed, would preclude the use of hybrid vehicles as NYC taxis because they are replete with warnings about vehicle modifications. For example, the Nissan Altima Hybrid manual states: "This vehicle should not be modified. Modification could affect its performance, safety, or durability and may even violate government regulations." The manuals even warn against replacing the upholstery on the seats because doing so "may prevent the side airbag system from activating correctly, disable the system or cause the side airbags to inflate accidentally, resulting in death or serious injury." (*See* Toyota Highlander Hybrid Manual, Appendix N.)

Before approving these hybrids, the TLC apparently did not read, or simply ignored, such warnings. That became public knowledge, when in August 2008, the TLC acknowledged that hybrid manufacturers had expressed concerns that the TLC-mandated vinyl seats – a mandated after-market modification – may impede the deployment of side-curtain and front airbags and

ordered all TLC-mandated vinyl seats removed. Many of the other TLC modifications, such as the partition discussed above, also endanger passengers in hybrids. Indeed, as reported in *The New York Times* and other major newspapers, Toyota – which is the largest manufacturer of hybrid vehicles in the world and which pioneered and currently licenses the hybrid technology to other motor vehicle manufacturers – refuses to support the use of its cars as New York City taxis due to their engineers' concerns. A Toyota spokesman said: "Our engineers are nervous about it because they were not designed for commercial use." (*The New York Times*, April 27, 2008.)

By contrast, the Ford Crown Victoria is a purpose-built, commercially produced "police/taxi package" vehicle that is designed to allow installation of a partition.

THE HYBRIDS HAVE A NUMBER OF ADDITIONAL PROBLEMS, IN PART, BECAUSE THEY ARE NOT DESIGNED FOR COMMERCIAL USE.

The hybrids approved by the TLC have a number of additional problems that render them unfit as NYC taxicabs, including: (a) the small size of the hybrids means that the critical components, including the expensive battery, are much more likely to be damaged or destroyed during accidents; (b) numerous components, including the battery and engine, may not function properly when driven 24/7 because they will rarely have the opportunity to cool down; (c) the bumper-height mismatch between the SUV hybrids and standard passenger cars increases the amount of damage sustained in accidents; and (d) many of the hybrids, including the Ford Escape and Nissan Altima, have difficulty climbing ramps or operating in confined spaces due to their highly variable throttle response.

SUGGESTIONS:

Hybrid taxis have not been adequately tested, particularly given the serious safety concerns discussed in this report. The TLC must perform a significant pilot program to ensure that the vehicles can withstand the demands of the 24/7 New York City taxi cycle, as has been the standard practice at the TLC up until now.

The Ford Crown Victoria should be used as the benchmark. It is a heavy-duty commercial vehicle that has proven itself as a New York City taxi over the last 25 years – the last six years as a purpose-built Long Wheel Base version – with hundreds of millions of miles of experience on the road.

The TLC or the automaker should conduct frontal, side, and rear impact tests on *all* seating positions in all TLC-authorized vehicles including the Crown Victoria LWB taxicab and the hybrid passenger vehicle models. These tests should be performed on vehicles outfitted with partitions and other mandated modifications. These tests should be done with a 95% male Anthropomorphic Test Dummy (ATD), representing a large male, and a 5% percentile ADT, representing a small female. The test protocol that should be used is the test protocol for the Federal Motor Vehicle Safety Standard (FMVSS) test modified by the addition of three additional rear seat occupants. All other vehicles should be judged by their ability to meet the Crown Victoria's high occupant protection standards.

Furthermore, the author strongly warns against utilizing small cars or cars that are not built for commercial use as New York City taxis. From an engineering standpoint, vehicles have to be designed for the duty cycle they are likely to encounter and cannot feature modifications that will compromise their safety systems.

It is the author's understanding that the TLC has already spent a significant amount of

time, effort, and money in order to find the "Taxi of Tomorrow" that is safe, accessible, *and* fuel-efficient – and that several manufacturers already have cars in late stages of development. It would be nothing less than a tragedy if we did not keep the proven Crown Victoria until the "Taxi of Tomorrow" is rolled out and thoroughly tested. We should not hastily switch to hybrids that will endanger New York City taxicab drivers and the riding public. We cannot ask the taxi riding public to be our involuntary crash test dummies.

DISCUSSION:

The author has prepared this report in a format designed to provide all interested stakeholders with an easy reference tool. The results of the analysis are presented in a question and answer format and are supplemented by photographic evidence of the test subject in various positions in taxicabs under study, as well as relevant charts, crash photos and excerpts from owners manuals.

DESCRIPTION OF THE AVAILABLE VEHICLES.

Four types of taxis were inspected in preparation for this report. These are the 2008 Ford Crown Victoria, the 2008 Ford Escape,[1] the 2008 Nissan Altima and the 2006 Toyota Highlander. Each vehicle was thoroughly inspected. These inspections included a total station, laser survey of each vehicle for dimensional data, including, but not be limited to, wheel-base, track, front overhang, rear overhang, rolling radius, available steer angle, available steer rate, weight distribution, seat height and eye position. (*See* Vehicle Drawings, Appendix B.)

The vehicles were inspected for interior clearance from all 5 interior seated positions. The author of this report, who is about 5'8" tall and 180 lbs. was utilized as a test subject for these interior clearance measurements. The author is fairly close to an average size man. It was determined that the interior clearance was fairly similar for all the small hybrid-type vehicles and the interior clearance was dramatically greater in the Ford Crown Victoria. The above baseline data on the vehicles inspected will allow direct comparison of vehicles involved in crashes to an undamaged vehicle profile. This will allow an accurate determination of vehicle crush profile. Further, all the data necessary to do a computer-aided, accident reconstruction via the typical

[1] Note: multiple Ford Escapes were inspected including hacked and non-hacked vehicles. In addition a crashed 2007 Ford Escape Taxi was also examined.

CRASH[2] and SMAC[3] computer models is in hand.

HOW DO OCCUPANT PROTECTION DEVICES FUNCTION IN STATE-OF THE-ART PASSENGER VEHICLES?

Vehicle crash tests available publicly are usually run at 30 and 35 mph. To give an idea of the forces generated at these speeds, a 30 mph crash is equivalent to a drop height of about 30 feet and a 35 mph crash is equivalent to a drop height of about 40.9 feet. This is the equivalent of taking a vehicle, lifting it by the rear bumper and raising the front bumper so it is 30 feet off the ground for a 30 mph crash and about 41 feet for a 35 mph crash then dropping it to the ground. This would be like dropping the vehicle on to a hard and unyielding surface such as a city concrete side walk, about the height of a 3 or 4 story building for the 30 and 35 mph crash test speeds respectively. Under normal circumstances, a person falling from a height of a 3 to 4 story building onto a hard, unyielding surface is likely to receive severe and life threatening injuries.

Unrestrained occupants in a 30 and 35 mph frontal crash will move forward and strike the interior of the vehicle at about 30 to 35 mph test speed. This would be the same as falling from that previously mentioned 3 to 4 story building and striking the available interior surfaces. For the driver, these surfaces would be the steering wheel, dashboard, windshield and knee bolster. The knee bolster is the lower portion of the dashboard at about the operator's knee level.

For the right front passenger in a frontal crash, the contact surfaces would be the windshield, dashboard and knee bolster. Rear seat occupants in frontal crashes tend to go forward and collide with the seat backs directly in front of them. In severe cases, rear seat occupants can even collide with a front seat occupant and have occupant to occupant collision.

[2] Calspan Reconstruction of Automobile Speeds on the Highway.

[3] Simulation Model of Automobile Collisions.

High velocity impacts with the interior surfaces are undesirable. Vehicle manufacturers take great pains to make the interior surfaces as benign as possible to absorb energy over the greatest possible crush to the interior, given other design restrictions and requirements. These surfaces are designed to absorb energy and have little spring back. The engineering term for this is high hysterisis materials. High hysterisis materials are analogous to a soft, putty-like materials. If a ball were made of this material, it would have virtually no bounce, unlike a super-ball which would bounce to almost the same height from which it was dropped. Low hysterisis (elastic) materials, those that are hard, strong and resilient surfaces, are to be avoided. Great efforts are made by vehicle manufacturers to smooth the contact surfaces to avoid focal loading of occupants should they strike those surfaces.

Three point unibelts (continuous belts) are most often used in passenger cars. These belts help to restrain occupants in a vehicle. These belts are typically applied to the strongest portion of the human body best suited to take heavy loading. They go diagonally, across the chest and sternum, and go over the hips below the iliac crest.

These seatbelts cannot be made without some stretch and spool out. Spool out is the extension of the belt, allowing the belt to tighten around the retraction spool. The retraction spool is the device that retracts the belt for storage when not in use. Modern seatbelt systems use torsion bars that limit the peak force in the seatbelt system. Sophisticated seatbelt systems have two-stage torsion bars that limit the force in the seatbelt system. Seatbelt forces must be limited to prevent injury from the seatbelt itself. This is done based on the size of the occupant. The larger and heavier the occupant, the more seatbelt force is desired. A lighter occupant needs lower seatbelt forces. This is to avoid injury from excessive seat belt loads. The occupant size information is determined by seat position, pressure on the seats and other sensors within the

vehicle. This allows the seatbelt system to adapt to the size of the occupant, a highly desirable feature, as not all people weigh the same. The larger and heavier the occupant, the greater the restraining forces that are required. Changing the interior upholstery in the vehicle can affect the function of the occupant classification system and the ability of the system to control the occupant restraint system. This could result in the failure of the vehicle to comply with governmental crash test requirements.

Frontal supplemental restraint systems (SRS, airbags) are also used to slow and retard occupants in vehicle crashes. The current SRS systems use a multistage-airbag that has two SRS inflation cartridges, a large and a small one. If the small one is ignited,[4] a "soft" bag will be deployed. If the larger inflation cartridge is used, a "medium" hardness bag will be deployed. If both cartridges are fired, then a "hard" bag will be deployed. Depending on the size of the occupant, the SRS control system will decide on the hardness of the bag. If an extremely small person is seated too close to the SRS, the SRS may not deploy. This is a highly sophisticated approach to occupant restraint. Making any changes to this complex occupant restraint system without in-depth knowledge is ill advised.

The deployment of an SRS can be dangerous in and of itself. The author has personally investigated an accident where this occurred and the driver of the vehicle lost her life as a result. This airbag system was an early single-stage system, and the driver was a person of a very small stature under five feet tall who sat very close to the steering wheel and on a pillow. The deployment of the SRS itself, while being a useful safety device, has risks for occupants seated too close to the SRS.

In addition to the above devices, seatbelt pretensioners are used for front seat occupants.

[4] The airbag inflation cartridge typically uses zinc azide, a rapidly burning pyrotechnic gas generator.

These are pyrotechnically driven devices utilizing similar propellants to the SRS cartridges. The purpose of the pretensioner is to pull on the seatbelt to take out any slack in the seatbelt system and pre-load the belt. This device is triggered when the sensor system detects a crash. This pretensioner also tends to pull the occupant back into the seat and remove any slack in the seat belt to maximize the belt's effectiveness. The pretensioner is designed to give the maximum available distance over which the seatbelts can act. Typical pretensioning forces that have been cited are around a 300 lb force. There are also some indications that even higher pretensioning forces in these seatbelt systems are desirable. The above safety devices are available to front seat occupants. There are no supplemental restraints or belt tensioners, to the author's knowledge, in the rear seats of any of the vehicles under study. The rear seat occupants only have simple, non-adaptive rear seat belts, much like the cars of the late 80's and early 90's used for front seat occupants.

The purpose of the devices, in the front seat positions, is to lengthen the time and distance over which the occupants decelerate in a frontal crash. These devices are only utilized in the front seats of the vehicle. This is no surprise, as the federal government only tests the front seat occupants in their staged frontal crash tests. The federal government spot checks the performance of manufacturers' vehicles and tests only the front seat occupants. There are no front or rear end crash tests for rear seat, adult occupants available for the vehicles of interest.

The federal government does not test rear occupant adult safety in front and rear crashes because of the dramatic differences in the occupant environment between the front seat and the rear seat. Front seat occupants must be protected from the dashboard, steering wheel, windshield and other hard surfaces. Rear seat occupants typically have a soft, benign, energy-absorbing seatback to cushion an impact. By adding the partition, however, that soft surface is turned into

a hard elastic partition, which might as well be a steel wall.

The approach to occupant protection is one wherein the time and distance over which the deceleration is applied is lengthened which will directly reduce the peak forces to which the occupants are subjected. The lower the peak forces which an occupant is subjected to, the less potential there is for injury. To put this into perspective, people slow their cars from 30 mph everyday without injury. If a high performance vehicle is considered doing a panic stop, it is possible to stop from 30 mph in 30 feet for an average deceleration of 1g. These forces are no more than the normal gravitation forces that one would experience on earth. Deceleration levels of 1g are not normally considered capable of producing injury.

If however an occupant is unrestrained in a vehicle and collides with the interior, that occupant is slowed over the compliance of the interior and the compliance of their body. For sake of explanation of this concept, if we assume a 30 mph crash, and a 6 inch distance over which the person will be decelerated, an average deceleration of 60 g's results. This is the average force during the deceleration. To put that into perspective, the person's effective weight will be 60 times what it would be normally. This would be like stacking another 59 people on top of that person. However, the real situation is even worse as the peak force will be far greater than the average force. The force will start at zero at initial contact and roughly ramp up to twice the average g-load to arrive at 120 g's. The peak force would be analogous to stacking 119 people of equal size and weight on the occupant. This is a highly undesirable situation and severe injury is a likely result.

The purpose of all aspects of the safety system discussed – the belt pretensioners, multistage airbags and the controlled spool out belt – is to lengthen the time and distance over which an occupant in a crash decelerates. The longer the time and distance, the lower the peak

forces and thereby the injuries produced. Sharp rises in the deceleration of the occupant are also avoided so as to minimize the peak forces applied to the occupant. The ideal circumstance is to have a steady deceleration level to minimize the peak force.

Stiff contact structures that the occupant can strike are even more undesirable. Elastic stiff structures are even worse, as they spring back after an impact, further increasing the change in velocity due to their elasticity, as the occupant is accelerated away from the contact surface as the surface rebounds. This further increases the change in velocity and the severity of the impact due to the spring back of elastic surfaces.

Manufacturers therefore assiduously avoid hard unyielding surfaces in the interiors of their vehicles. They tend to round all the surfaces that can be struck. They make the surfaces energy absorbing and they avoid elastic surfaces.

WHAT DOES THE NHTSA STAR CRASH RATING SYSTEM MEAN?

The star crash test ratings relate to the ability of vehicles to exceed the NHTSA minimum occupant safety requirements and reduce injury.

All vehicles sold in the United States have to be certified to meet all applicable Federal Motor Vehicle Safety Standards (FMVSS) on the date of manufacture. Placards must be affixed to each vehicle sold in the United States to certify compliance. These placards are often found on the B-pillar of most vehicles. The B-pillar is the post between the front and rear doors of a vehicle.

Auto manufacturers are not required to publish or provide this data to the federal government. The federal government does independent spot checks of vehicles for compliance and reports the results. The crash test reports are available on the internet at the following link: http://www-nrd.nhtsa.dot.gov/database/aspx/vehdb/queryvehicle.aspx.

The table below lists crash test results for front seat passengers in the vehicles studied in this report without any of the modifications required by TLC.

VEHICLE	SPEED	DRIVER HIC	CHEST ACCEL g	CHEST DEFLECTION mm	FEMURLOAD pounds	PASS HIC	CHEST ACCEL g	CHEST DEFLECTION mm	FEMUR L/R pounds	PASS/FAIL
90 Crown Victoria	29.6	268	44.7	NA	1410/932	219	33	NA	817/651	PASS
98 Crown Victoria	35.3	602.2	38.99	35.6	996/790.7	335	40.48	28.8	512/578	PASS
03 Crown Victoria	35.3	608	38	19.5	881/554	386	36	20.5	338/469	PASS
05 Chevy Malibu	34.98	367.7	36.6	27.1	719/677	362.7	38.9	29.6	1009/632	PASS
05 Toyota Camry LE	35.1	518	40	22.8	249/717	323	41	20.7	408/253	PASS
06 Toyota Prius	34.9	511	45.8	24.7	358/856	430	45.7	24.7	662/89.8	PASS
07 Toyota Camry	35.1	505	41	25	411/547	522	41	28	804/233	PASS
07 Nissan Altima	35.1	264	42	21	133/787	434	39	26	164/219	PASS
08 Ford Escape	34.6	518	50	32	1092/1330	478	38.8	26.8	1054/479	PASS
LIMITS	NA	1000	60	76mm	2250/2250	1000	60	76mm	2250/2286	

The criteria are defined as follows:

The HIC or head injury criteria limit is 1,000. The formula for the definition of head injury criteria is rather complex, but it is essentially a measure of head acceleration rates and duration. The criteria to pass a NHTSA crash test is a head injury criteria of less than 1000.

Chest deceleration is the maximum g-load encountered in the crash. The peak limit for chest deceleration is 60 g's. This means that the Anthropomorphic Test Dummy's (ATD) chest cannot be decelerated at a rate greater than 60 times the force of gravity. The higher the g-load, the higher the forces on the dummy.

Chest deflection is the amount the chest of the ATD deflects. The greater the deflection, the greater the chance for internal injuries.

Femur loads are the forces applied to the femur or the upper leg bones of the ATD in the

crash test. The limit is 2,250 lb force. The lower the femur load, the less likely that the femur and pelvic area will be injured.

The prior table indicates that all the vehicles that passed the requirements for 30 mph FMVSS 208 standard in a 35 mph New Car Assessment Procedure (NCAP). The worst data was found in the Ford Escape.

The NCAP test **provides data on front seat occupants in an unmodified vehicle**. There is simply no data on adult, belted, rear seat occupants.

HOW DOES THE NHTSA CRASH TEST PERFORMANCE OF THE FORD CROWN VICTORIA COMPARE TO THE CURRENTLY APPROVED HYBRIDS?

The Ford Crown Victoria has been subjected to NCAP 35 mph barrier crash tests. These crash tests results, along with comparative data for the various hybrid vehicles, are listed below in the table. This data is only valid for front seat occupant as there is no rear seat data.

The results from the prior table indicates that the Ford Crown Victoria provides some of the lowest occupant force. Some of the highest forces are with the Ford Escape. The NHTSA published a paper, Traffic Safety Facts, Research Note, "Passenger Vehicle Occupant Fatality Rates by Type and Size of Vehicle" D.O.T. HS 809 979 (Jan. 2006), *see* Appendix P, that finds that subcompact cars have the highest fatality rate and large passenger cars tended to have a substantially lower rate. The report also noted that large vans were the safest of all vehicles. With regard to rollovers, full size passenger cars are dramatically safer than any other category of vehicle. Graphs showing this data are also included for reference.

Lower values in the crash test means lower potential for injury. Further, the results indicate that the crash test severity would have to be substantially increased in the Ford Crown Victoria to equal these values found in the Ford Escape. The Ford Crown Victoria produces an additional margin of safety for the occupants. The good experience that the taxi industry has had

with the Ford Crown Victoria confirms that this data has a bearing on the real world performance of the Ford Crown Victoria.

The rear seat performance of all these vehicles is unknown except for the Crown Victoria which has shown good rear seat occupant protection performance in real world use. It is likely that a van type vehicle could readily provide the necessary occupant space with a partition.

ARE THE CURRENT NHTSA STAR SAFETY RATINGS OR SAFETY RATINGS FROM IIHS A SOUND BASE TO APPROVE THE VEHICLES FOR USE AS TAXIS IN NEW YORK CITY?

No. Both NHTSA and IIHS[5] run crash tests with test dummies in the front seat occupant position in frontal crashes. There are standards for the occupant protection requirements for front seat occupants. There are no requirements for rear seat occupants. NHTSA does not test adult size rear seat occupants in frontal crashes and only tests rear seat occupants in side-impacts. The data for front seat occupants who have the benefit of the belt pretensioner, airbags and a system that adapts the occupant protection system for the size and weight of the occupant, is not applicable to rear seat occupants. Since most passengers in New York City taxicabs ride in the rear seats, the NHTSA crash test data provides no basis for saying that the rear seat occupants in these vehicles are safe.

Further, NHTSA tests vehicles as manufactured without any sort of modification to the interior save for instrumentation to conduct the tests. New York City taxicabs are highly modified vehicles. They are fitted with a full width partition or an L-shaped partition. No vehicle testing of this configuration has been conducted by the NHTSA.

Beyond the above problems, which are sufficient in and of themselves to indicate that the NHTSA crash ratings are inapplicable to New York City taxicabs for rear seated occupants, there

[5] The Insurance Institute for Highway Safety.

is the additional problem of the interference of the side curtain airbag deployment, by the addition of a partition to the hybrid vehicles. All the hybrid vehicles under study had side curtain airbags. If either a full width partition or an L-shaped partition is fitted, this will substantially interfere with the deployment of the side curtain airbag. This side curtain airbag is a key part of the occupant protection system in side-impacts. This indicates that the side-impact data simply cannot be used as a basis at all for the evaluation of these vehicles to protect occupants in a side-impact. This is true for left side-impacts with the L-shaped partition and would be true for either side collisions with a full width partition.

One cannot merely say that all these cars have five-star crash test ratings, so therefore they are safe. There is no scientific basis for making such a claim.

WHAT IS THE EXPECTED EXCURSION OF OCCUPANTS IN A FRONTAL BARRIER CRASH?

Many crash test films were reviewed. The smaller hybrid vehicles show similar results, including the Nissan Altima. The largest percentage of the hybrid vehicles in the taxi fleet are Ford Escape Hybrids. Given that circumstance, the Ford Escape Hybrid was chosen for a detailed analysis.

The right front seat occupant position was chosen for the analysis. This represents the closest configuration to the rear-seat occupant in the available D.O.T. crash test database. The D.O.T. crash test that was analyzed was D.O.T. crash #6078. The associated report was also reviewed. Test #6078 was run at 35 mph, with the Anthropomorphic Test Dummy (ATD) restrained by the three-point belt system, the pretensioner and the airbag. This occupant restraint system is far more sophisticated than the rear seatbelt system that consists of a simple three-point unibelt.

The excursion of the ATD is far more limited due to the supplemental restraint system

(SRS, airbag) and the pretensioners. Therefore, if the excursion of the ATD for the right front seat is used to define the limit of excursion for a rear seat occupant, it will likely be an underestimate of both the excursion and speed of the ATD relative to the interior of the vehicle.

The crash test films are typically run at a 1000 frames per second. Every frame corresponds to approximately a 1,000th of a second. The images found in Appendix C were taken from the crash test every 10 frames from the initiation of movement of the ATD. **It can be readily seen that the ATD's head goes into the dashboard and disappears from view below the window sill of the passenger door.** (*See* Analysis of ADT excursions in frontal crash test of Ford Hybrid Escape, Appendix C.)

If the head excursion and velocity for the right front seated ATD is used for a basis for the rear seat passenger which does not have all the sophisticated restraint devices present for the front seat occupant, an under-estimate of the velocity and excursion of the rear seat passenger would likely result.

D.O.T. crash test #1382 of a 1990 Ford Crown Victoria, run at 30 mph, has some bearing on the issue of occupant protection for rear seat occupants. This early vehicle was equipped with a 3-point unibelt. This vehicle did not have belt pretensioners or airbags. Two frames from the view of the passenger side ATD are shown in Appendix D.

The frames show that the excursion of the ATD was similar to the excursion found in the Ford Escape and that the test dummy's head likely contacts the dashboard. Two addition photos show damage to the dashboard from this strike. (*See* 1990 Ford Crown Victoria interior images, Appendix E.) It must be kept in mind that this crash test was run at only 30 miles per hour and is far less severe than the 35 mph NCAP test. Large excursions of ATDs and therefore actual human beings would be substantially similar. Large excursions of occupants in high speed

collisions are expected.

It is obvious from the 1990 crash test run at a lower velocity with a less sophisticated occupant restraint system that high energy and velocity head strikes will be seen with the limited occupant space available in the hybrid vehicles. Further, these crash tests are run with average size males. Larger occupants will make more violent contact with a partition due to their greater stature.

ARE HEAD STRIKES AGAINST THE L- SHAPED PARTITION OR FULL WIDTH PARTITION EXPECTED IN A FRONTAL CRASH?

Yes. In a frontal crash, the rear seat occupant in a hybrid will strike his/her head against the partition, causing severe injury. The author, who is of approximately average stature at 5'8" conducted numerous interior clearance measurements on all the taxis understudy. The table below lists the taxis under consideration and their interior clearance measurements.

		2008 Ford Crown Victoria (with a 5 foot 8 inch 180 pound occupant)	2006 Toyota Highlander	2008 Ford Escape	2008 Altima
Forehead		2.2 to 2.3'	1.8'	1.8'	1.8'
Chin		2.2 to 2.3'	1.8'	1.8'	1.8'
Sternum		2.1 to 2.1'	0.3 to 0.4'	0.3 to 0.35'	0.2 to 0.3'
Knees L/R		0.6/0.6'	0.3/0.4'	0.3/0.35'	0.2/0.3'

It was determined that in all the hybrids, the author's head would come in contact with the L-shaped partition long before the excursion, based on the D.O.T. crash test analyzed, above would have been completed. The ATD was restrained by both the airbag and the belt pretensioners in the Ford Escape crash test #6078. (*See* Ford Escape 5/28/08, photos: 1-3, 1-10, 2-19, 2-20, 2-21, 2-25, 2-31, 2-32, Appendix F.)

This contact would occur with a hard and unyielding elastic, non-energy absorbing surface in all the hybrid vehicles under study. This contact would <u>not</u> occur with the Ford Crown Victoria LWB. In the Ford Crown Victoria, the author could place his chest on his

thighs, essentially completely doubling over and still have at least 2-1/2 inches of clearance to the top of the head. This was in the left front seated position where the interior clearance is minimized due to the angling of the partition, which is done to preserve driver space. (*See* Crown Victoria 5/30/08, photos: 4-1, 4-2, 4-16, 4-19, Appendix G.)

This interior occupant clearance will allow the seatbelt to restrain the occupant and precludes head strike to the hard upper elastic surfaces of the partition.

CAN ANY PARTITION BE USED IN THE HYBRID VEHICLES WITH SIDE CURTAIN AIRBAGS?

No. The installation of any sort of partition, either full width or L-shaped, will interfere with side curtain airbag deployment. A full width partition would block both side curtain airbags. A side curtain airbag is deployed to cover the side windows in a side-impact. This side curtain provides an energy absorbing airbag over the side windows of the vehicles. The Ford Crown Victoria does not have side curtain airbags; therefore, the installation of a partition is not an issue with the Crown Victoria. It is likely that this technology was not applied to the Ford Crown Victoria because of its good side-impact protection without side curtain airbags. Moreover, the Crown Victoria is sold with a taxi/police package, and the manufacturers expect it to be fitted with a partition.

The author was made aware of a TLC rule that requires 6 inches of space between the side vehicle wall and the partition. However, there was nothing close to a 6 inch gap in any of the hybrid taxis that the author inspected for this report. (*See* partition photos, Appendix O.) Such a gap would most certainly defeat the purpose of a partition, which is to protect the driver from robbery, assault, injury or death that may occur on the job.

IS THE L-SHAPED PARTITION PARTICULARLY DANGEROUS?

Yes. The situation in side-impacts in vehicles with the L-shaped partition is cause for

serious concern. The fore-aft wall of the partition lies between the right side of the center floor console and the left side of the right front passenger seat and presents hard elastic non-yielding surfaces with cutting edges. The distance between the right side of the operator's head is such that contacts in a right side, side-impact would be expected. **The three-point unibelt is not effective in preventing the excursion of the upper torso and head in a right side, side-impact.** This lack of restraint will result in the right side of the **driver's head striking the hard, unyielding elastic surface of the partition** with no significant change in velocity with the fore-aft sidewall of the L- shaped partition. This impact configuration can have deadly consequences. (*See* Ford Escape 5/28/08, photos: 3-21 & 3-22 for potential contact, Appendix H.)

The same situation exists for the right front seated passenger in a left side, side-impact collision. The passenger's left shoulder is restrained by direct contact with the partition, but the head is not. The left side of the passenger's head will strike the partition at the change in velocity for the struck taxi in the left side, side-impact. The passenger's head will be totally unrestrained and not limited in anyway by the seatbelt system. (*See* Ford Escape 5/28/08, photos: 1-16 & 1-17, Appendix H.)

Beyond the above problems with the lateral surfaces of the L-shaped partition, there are problems with the corner of the partition. This portion of the partition is very ridged and elastic. The sharp edges of the access window in the lateral wall also present cutting edges for severe lacerations and provide focal loading which will enhance the injuries that are produced as a result of these sharp edges. Such surfaces are assiduously avoided by modern motor vehicle manufacturers. (*See* Ford Escape 5/28/08, photos: 1-18, Appendix H.)

<u>The driver's seat is particularly dangerous.</u>

Moreover, the front left seat, which is occupied by the driver is particularly

dangerous for a number of additional reasons. **The hybrid vehicles, due to the L-shaped partition and their small size, limit the reclining of the driver's seatback to allow those drivers to recline their seats (as suggested by the owners manuals) and obtain the necessary clearance to the steering wheel mounted airbag.** Preserving the driver's occupant space is important for large and heavy drivers. If this space is compromised, drivers will sit too close to the airbag. Occupants sitting too close to the airbag can be injured or even killed by the airbag deployment itself, as has been previously discussed in this report. Also, in the L-shaped partition, drivers face a terrible glare in the window on the right hand side, making it very dangerous, especially at night. Finally, drivers are too constricted in the box that the L-shaped partition creates and may have extreme difficulty escaping from an accident with a jammed driver's door. Responders may also have difficulty providing aid to a driver pinned in a vehicle and surrounded by an L-shaped partition.

<u>The L-shape partition is not securely mounted, which can lead to dislodgment and injury</u>.

The L-shaped partition is mounted adjacent to the driver's B-pillar (the post between the driver and passenger door) and along the right side of the center console. The partition is typically fastened to the B-pillar, the center console and the dashboard plastic. Given the construction of modern vehicles, access to the sheet-metal body structure of the vehicle is extremely difficult in the center console/center dashboard area. Many component parts of the dashboard, floor console and other associated interior components would have to be cut away to gain access to the actual sheet-metal body structure of the vehicle. Given that circumstance, the L-shaped partition is often mounted to the right side of the center console or the available plastic surfaces readily accessible in the interior of the vehicle. There are no structural components of the vehicle within these areas. The available structures have limited strength due to the need to

provide an energy absorbing surface. These components were not designed to support the forces produced by the partition in a vehicle crash.

The inspection of the crashed, subject 2007 Ford Escape demonstrates issues with attempting to mount the L-shaped partition in the Escape. Numerous failures of the mounting system occurred. The peak g-load of this crash was estimated at 23.6 g's. This means that the mounts of the partition would have had to have a minimum strength of about 23.6 times the weight of the partition. The photos in Appendix I show the various failures of the attachment points. (*See* Ford Escape 5/28/08, photos: 1-14, 1-16, 1-17, 1-18, 1-19, 4-8, 4-9, 4-10, Appendix I.)

The mounting of the partition was grossly inadequate and a thorough engineering study of a more appropriate mounting system is clearly required to retain this structure so as to avoid it dislodging and injuring rear seat occupants.

DOES THE CURRENT FULL WIDTH PARTITION IN THE FORD CROWN VICTORIA LONG WHEEL BASE PRESENT ANY SAFETY HAZARDS?

No. Due to the abundant occupant space between the backseat and the partition, the full width partition in the Ford Crown Victoria LWB has performed well in protecting both the driver and the taxi riding public. The full width partition still has the same hard, inelastic, unyielding surfaces of the L-shaped partition, but they are distal from rear seat occupants. This cushion of occupant space allows the full expected excursion of a belted rear seat occupant which precludes contact with the hard elastic surfaces of the upper portion of the partition.

The area with the least clearance for a rear seat passenger is a left rear seat position due to the angling of the partition to preserve driver's occupant space. The left, rear seated position has approximately 2.5 inches of clearance between the top of the left rear seat occupant's head and the partition. This is assuming a full 90 degree flexion of the upper torso. This places the chest

of the occupant against their thighs. This clearance will preclude significant contact with the partition. Should any contacts occur with a partition, they will be at a steep angle yielding a side swiping-type of contact. Since the contact is low on the partition, where there can be energy absorbing padding, this provides a very benign striking surface for the left rear seated occupant. This interior configuration is far more desirable.

The partition is flat and smooth. Flat, smooth surfaces tend to mitigate the adverse effects of any head strike. Further since that area is non-transparent it can be readily padded with energy absorbing foam which again makes the surface even more benign.

The conventional, full width partition in the stretch Ford Crown Victoria is mounted to sheet-metal structure of the B-pillars (the post between the front and rear seats). The access to the strong structure of the vehicle yields a very secure mount for the partition. This mounting also allows the partition to become an additional reinforcing bulkhead to the vehicle enhancing the vehicle strength and rigidity. The partition will also assist in the resistance of the vehicle to intrusion from side-impacts which is a highly desirable feature. The partition does this by transmitting the load from the B-pillar on one side of the vehicle to the B-pillar on the other side of the vehicle. This forms a reinforcing bulkhead, a highly effective and desirable feature.

The conventional, full width partition does not present a safety hazard to a belted rear seated occupants in the Crown Victoria Long Wheel Base due to the abundant occupant space. The hybrid vehicles, due to their small size, cannot provide this space and therefore have serious problems. There are few safety issues with the full width partition given the flat, padded benign energy absorbing surface provided to rear seated occupants, should any head strike occur. The full width partition provides a mid-vehicle bulkhead to reinforce the vehicle and reduce intrusion in side-impacts.

ARE THERE ANY SAFETY ISSUES WITH THE STABILITY/ROLLOVER RESISTANCE OF THE HYBRID SUV TYPE TAXIS?

Yes. The Ford Escape is more likely to roll over than the Ford Crown Victoria. A preliminary analysis for the stability of the Ford Crown Victoria and the Ford Escape Hybrid was conducted. The Ford Crown Victoria has a five-star rollover rating and the Ford Escape has a three-star rating. It was assumed for the analysis that both vehicles were in the middle of the stability rating for the star rating for that they were assigned. The author also assumed the vehicles were to be loaded to the maximum allowable passenger load per the tire placard on the respective vehicles. The uncompressed seat height was utilized in combination with the expected distance between the seated passenger's center of gravity and the location where they would be seated on the seat. It was determined that even with a six passenger load or 1,100 lbs. of load, the Ford Crown Victoria still had a very high, four-star rating. Doing the same analysis with the Ford Escape, it was determined that the three-star rating would be lowered to a low two-star rating and very close to a one-star rating. Low star ratings in the area of stability are undesirable, as these vehicles are over-represented in rollover crashes. One only has to look at the Ford manual to find a warning in regard to the operation of vehicles such as the Ford Escape.

There are special admonitions that more care is to be taken when the vehicle is loaded. Further, the manual states that sharp turns are to be avoided.

One only has to spend a short time watching New York City traffic to see that sharp turns and aggressive maneuvering through traffic often occurs. This is not a problem with the Ford Crown Victoria due to its low Center of Gravity (C.G.) and low seat height. It can readily become a problem with a Ford Escape, due to its high C.G. and relatively high seat positions. Further, NYC streets are far from perfect. Discontinuities in the road surface will help to trip SUV-type vehicles and increase the potential for rollover.[6]

ARE THERE ANY ISSUES IN REGARD TO CRITICAL COMPONENTS CLOSE TO THE ENDS OF THE HYBRID VEHICLE?

Yes. The small size of the hybrids means that the critical components of the hybrids including the expensive battery and radiator are more likely to be damaged or destroyed during accidents. Critical safety components that are necessary for the vehicle to operate should be as distal from the front and rear of the vehicle as possible. The purpose of this addition of space allows those components to survive a vehicle crash.

Radiator/Air Conditioning Condenser:

The more distance there is between the front of the vehicle and the radiator condenser and the radiator, the less likely these rather expensive components will be damaged. There are also environmental concerns in that it is undesirable to spill antifreeze onto the roadway. Some antifreeze formulations are actually poisonous.[7] Further, it is undesirable to release Freon into the atmosphere due to damage to the ozone layer. In the Nissan Altima, it was determined that

[6] The 2009 Ford Escape Hybrid has a stability control system, which helps to prevent yaw (the vehicle sliding sideways) and the resulting roll over.

[7] Some conventional antifreeze is poisonous and has a sweet taste. Due to this characteristic, animals will drink the antifreeze, which can be deadly.

there was approximately 8.9 to 9.6 inches of space between the front of the Altima and its condenser and radiator.[8] (*See* Nissan Altima 5/28/08, photo: 1-36, Appendix J.)

It was determined that the distance in the Ford Crown Victoria was more than 20 inches or about twice the distance back. (*See* Crown Victoria 5/30/08, photos: 2-28 & 2-29[9], Appendix K.) This means that in a frontal crash the Ford Crown Victoria is far less likely to have intrusion into these areas. This avoids the issue of fluid spills and Freon leakage to the environment. Vehicles that have ruptured radiators cannot be driven any significant distance and will require towing from the accident scene. Disabled vehicles, stuck waiting for tow-trucks cause more traffic delays. The Ford Crown Victoria is far less likely to need a tow-truck than the Nissan Altima.

Fuel Tank and Battery Pack:

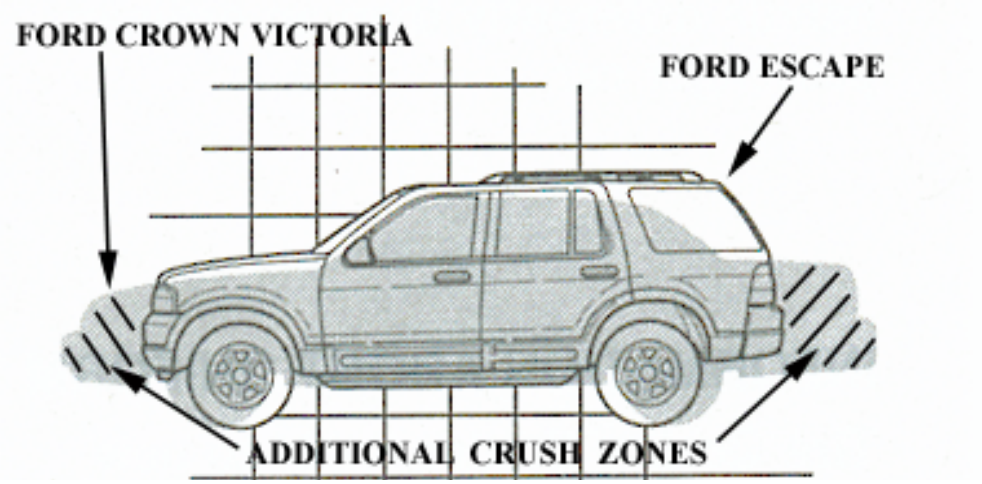
The fuel tank of the Ford Crown Victoria is more than 38 inches from the rear of the vehicle. (*See* Crown Victoria 5/30/08, photos: 2-30, 2-32, 2-33, Appendix K.) This great distance assures that in anything but the most violent, severe collision, there will be no intrusion into the fuel tank area of the Ford Crown Victoria.

The Ford Escape is quite different in that regard. The battery pack on the Ford Escape is located approximately 11 inches from the face of the rear bumper. (*See* 2008 Ford Escape 5/28/08, photos: 1-1 & 1-2, Appendix L.) This is less than one third the distance in the Ford Crown Victoria. It will not take much of an impact to intrude on the battery pack area of the Ford Escape.

[8] When the Altima crash test is viewed, the effect of the mounting location is readily apparent as the crash test barrier is showered with coolant.

[9] Note: the scale used is in decimal feet 1.7 feet = 20.4 inches.

In the author's study of a crashed Ford Escape, it was determined that the components of the battery pack were crushed, requiring replacement of the battery pack. Further, the battery pack was pushed up through the cargo floor. (*See* Ford Escape 5/22/08, photos: 3-4, 3-5, 3-6, Appendix M.)



The diagram above, from page 147 of the Ford Escape Manual, graphically shows the dramatic difference in crush zones, between the Crown Victoria and the Escape.

ARE THERE ANY DRIVEABILITY ISSUES THAT COULD AFFECT THE SAFETY OF HYBRID VEHICLES IN TAXI OPERATION?

Yes. Many of the hybrids have difficulty climbing ramps or operating in confined spaces due to their highly variable throttle response. During the inspection of the various taxis, it was necessary to utilize the author's weigh system to weigh the vehicles. The weigh system utilized ramps that are readily climbed by virtually all passenger cars. Difficulties, however, were encountered with the hybrid vehicles. When an attempt was made to have the Ford Escape climb these ramps, the Ford Escape simply would not climb it, despite full throttle operation. A run at the ramps was required. If the internal combustion engine in these vehicles could be forced to operate, the vehicle probably would have enough power to climb the ramp but under the

circumstances the engine management/hybrid system chose not to allow the engine to power up the vehicle.

The situation was more “interesting” in the Nissan Altima. When an attempt was made to climb the ramps, the internal combustion engine would startup and shut down as the throttle was modulated. This would change the throttle response in the available power to the operator’s foot. It was challenging to climb the ramps and get on the scales in a controlled fashion.

The rationale for bringing this issue to light is that steep ramps are not an uncommon feature in New York City. Having a vehicle with highly variable throttle response to operator input can provide real control difficulties in confined spaces. This is especially critical when there are pedestrians in the area. Linear, predictable throttle response is desired. Conventional vehicles provide this characteristic, but several hybrid vehicles that were evaluated did not demonstrate this characteristic and were difficult to control in that special circumstance.

DO THE SUVs PRESENT ANY POTENTIAL FOR BUMPER MISMATCH WITH STANDARD VEHICLES?

Yes. The bumper mismatch between SUVs and standard passenger vehicles produces a large amount of damage in accidents. In the crashed 2007 Escape Hybrid taxi, there was an under-ride by the striking vehicle, which was a standard passenger vehicle that under rode the rear of the Ford Escape Hybrid. The physical evidence would tend to indicate that the ride heights of both vehicles were essentially normal. This indicates that there was not any great brake dive on the striking vehicle or any amount of great bumper lift on the struck vehicle. SUV type vehicles tend to have high front and rear bumper structures so as to allow relatively steep departure and approach angles. This is important for off-road operation. This characteristic is unnecessary for operation on New York City streets.

There is no specific bumper height standard published by the NHTSA in the Federal

Motor Vehicle Safety Standards (FMVSS). The FMVSS do not give a bumper height standard, but do tell manufacturers they will test bumpers in passenger cars between a height of 16 and 20 inches. Given that circumstance, it is no surprise that bumpers on most passenger cars are between these two dimensions.[10] The Highlander bumper is almost 18 ¾ inches off the ground, and the top of the standard passenger car bumper is only 20 inches off the ground. There is, therefore, relatively little overlap between these two structures. If there is a small amount of brake dive on the striking vehicle or a little bit of bumper rise due to braking occurs on the struck vehicle, then an under-ride collision will result. This results in the relatively soft body structure of the striking vehicle, making contact with the rear bumper of the struck vehicle. This characteristic produces large amounts of damage to the striking vehicle and in the case of the Ford Hybrid, given that there is only 11 inches of crush to the battery box, this allows intrusion into the battery box area. This helps to explain why the battery pack was pushed up through the cargo floor in the crashed Ford Escape. This battery pack damage along with the other damage, resulted in a vehicle which was a total loss.

Given the above discussion, the suitability of SUV type vehicles for New York City taxicab use is highly questionable at best.

WHAT WAS THE SEVERITY OF THE REAR END COLLISION INVOLVING THE 2007 FORD ESCAPE HYBRID TAXI?

The 2007 Ford Escape Hybrid taxi was totaled even though the crash was relatively minor. The g-load experienced in the Ford Escape Hybrid was 40% greater than that would be experienced in the Ford Crown Victoria.

The damaged 2007 Ford Escape taxi was inspected, weighed and photographed. The collision damage profile was measured. The average crush for the rear of the vehicle was

[10] SUV's, however, do not have to comply with this standard.

estimated to average the damage at three levels. The data from these measurements along with other vehicle parameters were inputted into the ED-CRASH computer program. The change in velocity for the collision was calculated at 19.1 mph. Air gap adjusted front stiffness was used for this analysis, as there is no public sector, rear end stiffness data on the Ford Escape. The peak force in the collision was about 92,373 lbs force. The peak g-load was 23.6 g's.

A comparative ED-CRASH run was done with a 2008 Ford Crown Victoria LWB. The collision severity was adjusted to match the crush energy of the Escape collision. The results of this analysis indicate that the change in velocity for the Ford Crown Victoria would be less than the change in velocity for the Escape. The Delta-V for the Ford Escape was 19.1 mph. The Delta-V for the Ford Crown Victoria would be 18.4 mph. The peak force in the Escape is 92,373 lbs force. The peak force in the Ford Crown Victoria is 75,134 lbs force. The force in the Crown Victoria is about 81.3 % of the peak force in the Escape. The Ford Crown Victoria's average crush was 11.2 inches. This compares with about 8.7 inches of crush with the Ford Escape. The equivalent crush for the Crown Victoria was 129% more than the crush of the Ford Escape. This resulted in a peak g-load in the Escape of 23.6 g while only 16.8 g were produced in the Crown Victoria. **The g-load that would be experienced in the Ford Escape Hybrid would be more than 40% higher than the g-load that would be experienced in the Ford Crown Victoria. A 40% reduction in the peak g-load during a crash is highly significant and will dramatically reduce the potential for injury to the occupants in the vehicle which is subjected to lower g-loads.** This yet again proves the benefit of the large and relatively soft crush zones in the Ford Crown Victoria. The Crown Victoria due to its layout, size and body structure can afford to have these soft crush zones. The Ford Escape, due to its small size, cannot.

The Ford Escape experienced severe damage to its rear mounted battery pack. The Ford Crown Victoria on the other hand would have to crush another 26 inches more before getting to the bulkhead aft to the fuel tank. Clearly, this large crush zone of the Ford Crown Victoria provides much more protection to critical components of the Crown Victoria. The Ford Escape, due to its small size, cannot provide this level of protection. The Ford Crown Victoria also produces lower force in the collision which tends to reduce the potential for occupant injury.

DO THE OWNERS MANUALS OF THE VARIOUS HYBRID VEHICLES WARN AGAINST VEHICLE MODIFICATION?

Yes. The owners manuals of hybrid vehicles have warnings against modifying the vehicles. Excerpts from various portions of the owners manuals of the various hybrid vehicles will be quoted and their concerns raised by those warnings will be addressed. Copies of relevant pages from the manuals may be found in Appendix N.

Ford Escape Hybrid:

The Ford Escape Hybrid manual states: *"Do not put anything over the airbag module. Placing objects on or over the airbag inflation area may cause those objects to be propelled by the airbag into your face and torso causing serious injury."* (p.120) This warning is of serious concern with regard to the addition of partitions, which either go over the side curtain airbag or are immediately adjacent to the passenger front airbag. A partition applied to the Ford Escape will also violate the following warnings:

> *Do not place objects or mount equipment on or near the headliner at the siderail that may come into contact with a deploying Safety Canopy. Failure to follow these instructions may increase the risk of personal injury in the event of a collision.* (p.131)
>
> *Do not attempt to service, repair, or modify the Safety Canopy system, its fuses, the A, B, or C pillar trim, or the headliner on a vehicle containing a Safety Canopy.* (p.131)
>
> The Ford Escape manual also warns against any modifications to the seats: *"Any*

alteration/modification to the front passenger seat may affect the performance of the front passenger sensing system." (p.128) Because the Ford Escape (like all the other hybrids approved by the TLC) is not originally designed as a taxi or police vehicle, it is manufactured with a typical passenger car interior. Until early August, when the TLC was informed by hybrid manufacturers that such modification was dangerous, the TLC mandated that taxicabs have heavy duty vinyl seat covers so that they could be easily cleaned. Adding vinyl seats/covers to the hybrids after their manufacturer can affect the performance of the front passenger sensing system. This front passenger sensing system controls the function and deployment of the passenger airbag. Changing the characteristics of the airbag system could result in failure to meet federal crash worthiness standards.

Toyota Camry Hybrid:

Toyota Motor Corporation repeatedly warns in its manuals that its vehicles should not be modified. Toyota even warns that modifications could well cause these vehicles to violate federal regulations. For example, the Toyota Camry manual states:

> *A wide variety of non-genuine spare parts and accessories for Toyota vehicles are currently available on the market. You should know that these parts are not covered by Toyota warranty and that Toyota is not responsible for their performance, repair, or replacement, or for any damage they may cause to, or adverse effect they may have on, your Toyota vehicle. This vehicle should not be modified with non-genuine Toyota products. Modification with non-genuine Toyota products could affect its performance, safety or durability and may even violate governmental regulations. In addition, damage or performance problems resulting from the modification may not be covered under warranty.*

(p.16)

The Camry manual also contains specific warnings against installing items in the areas where the partition is installed. For example, the manual states: *"Do not attach anything to areas such as the door, windshield glass, side door glass, front and rear pillars, roof side rail or assist grip."* (p. 99)

Like the Ford Escape manual, the Camry manual prohibits the installation of the TLC mandated vinyl seats. It states: *"Do not use seat accessories which cover the parts where the SRS side airbags inflate as they may interfere with inflation of the airbags."* (p.99) Later, the manual states: *"Do not modify or remove the front seats."* (p.105) As explained before, such modification will interfere with the proper operation of the occupant classification system and could cause the car to fail federal motor vehicle crash worthiness requirements.

The Camry manual also warns, on page 105, that front seats should not be reclined so that they touch the rear seat because doing so may cause the airbag not to deploy properly. The Lexan placard holders that have been applied to the front seats of taxis equipped with the L-shaped partition may cause a similar problem.

Toyota Highlander Hybrid:

The warnings in the Toyota Highlander Hybrid owners manual are similar to those discussed above. As to modification in general, it states:

> *This vehicle should not be modified with non-genuine Toyota products. Modification with non-genuine Toyota products could affect its performance, safety or durability and may even violate governmental regulations. In addition, damage or performance problems resulting from the modification may not be covered under warranty."* (p. vii)

Like the other manuals, the Highlander warnings also prohibit the installation of the TLC vinyl seats:

> *Do not use seat accessories which cover the area where the side airbags inflate. Such accessories may prevent the side airbags from activating correctly, causing death or serious injury.* (p.51)

> *Do not modify or replace the seats or upholstery of the seats with side-impact airbags. Such changes may prevent the side airbag system from activating correctly, disable the system or cause the side airbags to inflate accidentally, resulting in death or serious injury.* (p.94)

The Highlander manual also warns against mounting objects as small as a cup holder

adjacent to the side-impact airbag deployment areas. No objects are to be attached to the area where the side curtain airbag activates. (p. 93) This precludes the addition of any partition (full width or L-shaped) in the vehicle.

Toyota Prius Hybrid:

The Toyota Prius has similar warnings as the above manuals. It has the verbatim general warning regarding modification as the Highlander. Prohibiting the installation of vinyl seats, it states the following:

> *Do not use seat accessories which cover the area where the side airbags inflate. Such accessories may prevent the side airbags from activating correctly, causing death or serious injury. . . . Do not modify or replace the seats or upholstery of the seats with side airbags. Such change may prevent the side airbag system from activating correctly, disable the system or cause the side airbags to inflate accidentally, resulting in death or serious injury.* (p.53)

> Prohibiting the installation of a partition in this vehicle, it states:

> *Do not disassemble or repair the front and rear pillars and roof side rail containing the curtain shield airbags. Such changes may disable the system or cause the curtain shield airbags to inflate accidentally, resulting in death or serious injury. Failure to follow these instructions can result in death or serious injury. Consult your Toyota dealer about any repair and modification.* (p.79)

Nissan Altima Hybrid:

Like the other manuals, the 2008 Nissan Altima Hybrid manual prohibits any modification, stating the following:

> *Modification of your vehicle. This vehicle should not be modified. Modification could affect its performance, safety or durability and may even violate governmental regulations. In addition, damage or performance problems resulting from modifications may not be covered under NISSAN warranties.* (foreword)

> *Do not make unauthorized changes to your vehicle's electrical system, suspension system or front end structure. This could affect proper operation of the supplemental front air bag system.* (p. 1-45)

There is an additional warning on page 1-45 stating that modifying or tampering with the front

passenger seat may result in serious personal injury.

Like the other manuals, the Altima manual prohibits the addition of vinyl seat covers. The Altima manual warns not to change the front seats by placing material on the seat cushion or by installing additional trim material, such as seat covers.

The manual also warns, on page 1-47, against making unauthorized changes to the vehicles electrical system, suspension system or side panels. The manual states that doing so *"could affect proper operation of the seat-mounted side-impact supplemental airbag and roof-mounted, curtain side-impact supplemental airbag system."* The addition of a partition or vinyl seats is prohibited by this warning. The manual further states that *"work around and on the roof-mounted curtains side-impact supplemental airbag system should be done by a NISSAN dealer. Installation of electrical equipment should be done by a NISSAN dealer."* This warning is not followed, as hybrid vehicles that are normally modified by after-market suppliers.