Equal Spacing NOT Required for Speed from Crush Calculations

or

Equally Spaced Crush measurements
- take them in the field or in the office -
which is the better location?

The background paper for the Poster Presentation given at WREX2016

by

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Equal Spacing NOT Required for Speed from Crush Calculations

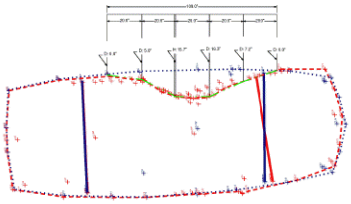
(Equally spaced Crush measurements - in the field or in the office - which is the better location?)

In the Field which is easier ...
Measure to "critical points".... or ...Measure "Equally Spaced" crush points?

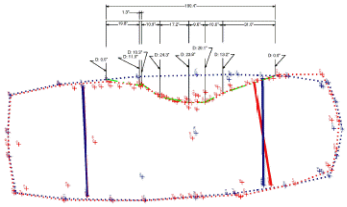



Given the above damage and final rest alignment, measurements of damage were made using photogrammetry. Using Force Balance, some Speed Calculations were made to compare the results of equal vs. non-equal spacing measurements.

EQUAL SPACING **NON-EQUAL SPACING**

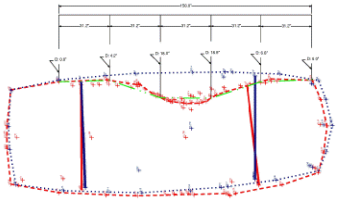


Crush Length ~100 inches

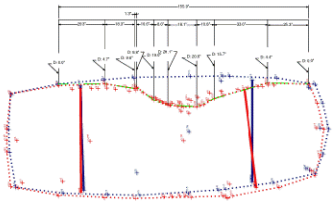


From a Force Balance Analysis using the Bullet Vehicle as the "Known" vehicle, at the +1 Std Dev line for the Stiffness values

Equal Spacing closing speed = 39.9 mph
NON-Equal Spacing Closing speed = 39.3 mph



Crush Length ~ 156 inches



From a Force Balance Analysis using the Bullet Vehicle as the "Known" vehicle, at the +1 Std Dev line for the Stiffness values

Equal Spacing closing speed = 41.5 mph
NON-Equal Spacing Closing speed = 36.7 mph

In the field, which length do you choose? Why? Do you want to lose crush profile detail by taking only equal space measurements in the field, just because your software does not allow for non-equal spacing?
Isn't it easier to simply measure to the "critical points" then use those same points for your crush measurement?
If your software does not allow non-equal spacing, where should you do the equal spacing measurements ...

In the field or in the office?

Download the background paper at - www.4n6xprt.com/WREX2016-4N6XPRT-poster.pdf

OVERVIEW

There is a mode of thought that crush measurements must be taken at equally spaced points along a field indentation crush length. This thought process stems in large part from what is commonly referred to as "The Tumbas Protocol" - "Measuring Protocol for Quantifying Vehicle Damage from an Energy Point of View" Tumbas and Smith (SAE 880072) - which lays out a process for taking crush measurements. Another contributor to this thought process is that the commonly presented crush formulas for calculating A-B-G Stiffness values and Speed from Crush REQUIRE that the crush measurements be equally spaced. If these formulas are used when the crush measurements are not equally spaced, some of the simplifications in the formulas which are allowed with equally spaced measurements will create errors when the measurements ARE NOT equally spaced.

So, the first series of questions is, just because some formula's require equally spaced crush measurements, is it a good idea, or even required, to take the equally spaced measurements in the field? Or is the equal spaced measurement process better completed in the office? Why? When you are in the field, would it not be better to take crush measurements at the "critical"/bend/inflection points, which will almost certainly be non-equally spaced? Why? What are the positives, and negatives, of taking measurements at the critical points (non-equally spaced) vs. equally spaced measurements when you are in the field?

The second series of questions is the focus of the poster: are equally spaced crush measurements REQUIRED in order to complete speed from crush calculations? Why? Which yield the more accurate results, equally or non-equally spaced measurements? Why?

The following data and analysis will attempt to answer these, as well as a number of other questions.

DATA SOURCE FOR ANALYSIS

The data presented in the Poster Session and this background paper are a result of the second Crash Test conducted at the Institute of Police Technology and Management's Special Problems in Traffic Crash Reconstruction, May 20-24, 2013. This test had a 2006 Chevrolet Impala impacting a 1995 Cadillac Eldorado on the driver's side between the front axle and the 'B' pillar. Both vehicles were moving at the moment of impact.

Both pre-crash and post-crash photographs were taken of the vehicles and analyzed with iWitness photogrammetry software to provide before and after profiles of the two vehicles. An overlay of the pre-crash and post-crash profiles was completed in CAD Zone software, after which crush measurements and alignment measurements were taken.

Field measurements were taken of the crush to both vehicles after the crash test was completed and the vehicles were moved to the storage area. These measurements are provided in Appendix 1 for completeness and comparison purposes to the crush measurements obtained from photogrammetry. No analysis of these measurements was conducted for the poster or this paper.

The excerpted pertinent pages from the Crash Test Summary presentation (Appendix 2) indicate the speed of the Eldorado at impact was 19-21 mph and the speed of the Impala at impact was 40-45 mph. The post impact speed of the Eldorado was 22-23 mph with a crash impulse time of 150 milliseconds. The post impact speed of the Impala was 22-29 mph with a crash impulse time of 150 milliseconds.

The Impala X-vector delta-v was 22-23 mph and the Y-vector delta-v was 9-10 mph.

CRASHED VEHICLES

A quick look at the vehicles shows the potential for several measurement issues.

2006 Chevrolet Impala





What is your Field “L”? Where do you measure to on the vehicle to get your crush measurements? Bumper cover? Bumper support bar? Hood? If hood, where on the hood? How do you account for the missing material between the bumper support bar and the face of the bumper cover? Is the “twist” that seems to be present on the right front fender important, or just part of the normal fender shape? If you use an equal measurement process, what are you going to lose in the way of crush profile detail?

1995 Cadillac Eldorado

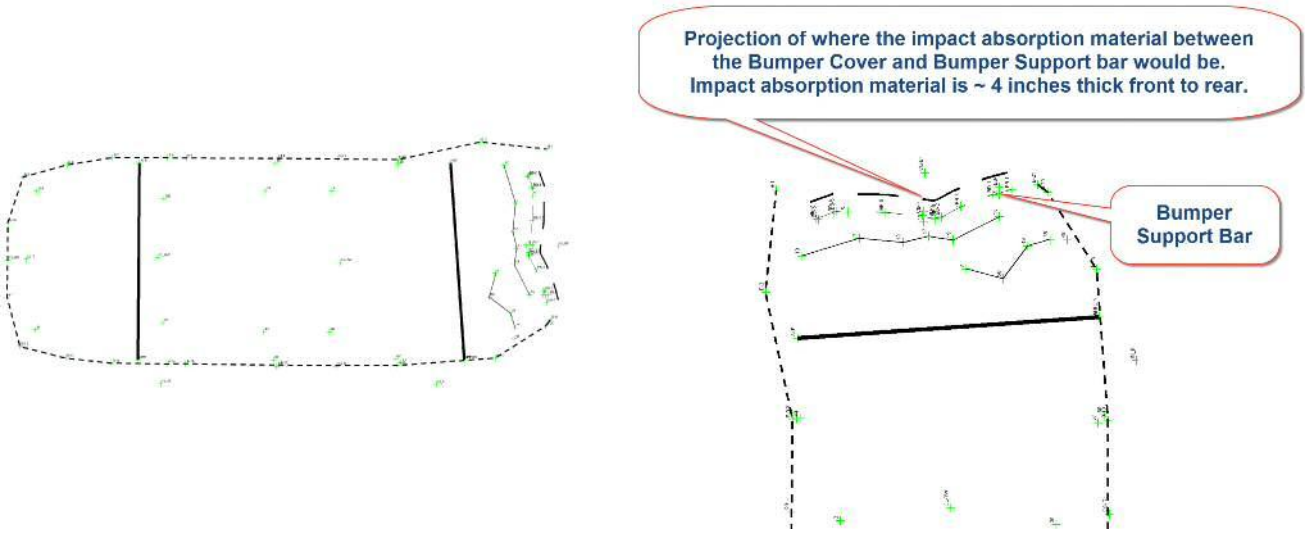
What is your Field “L”? Where does it Start? Stop? It looks like there may be hinge separation at the “A” pillar - do you average the door sill measurements with the maximum crush measurements? Do you average in the field, or do you measure at the sill line and maximum (~bumper level) crush line and record both depths? There appears to be a twist (or bowing) starting at the firewall, is this significant? Do you apply/use a bowing constant? If you use an equal measurement process, what are you going to lose in the way of crush profile detail?

Finally, back to the REAL question, should you worry about the above questions in the field, or back in the office?

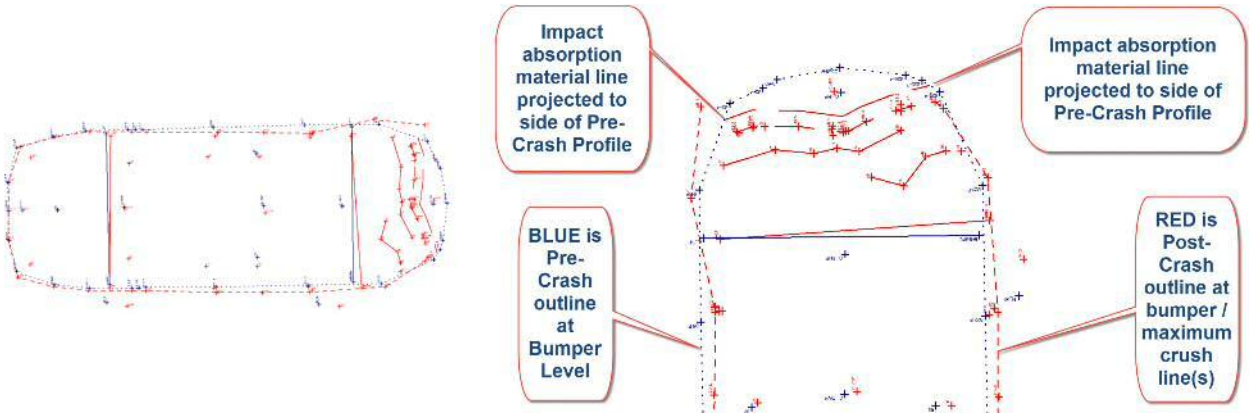
Through the use of photographs, which were then processed through Photogrammetry, what was deemed to be the “critical” crush features were documented in the field. The Photogrammetry data was then imported into CAD Zone, resulting in the following crush profiles

CRUSH PROFILES

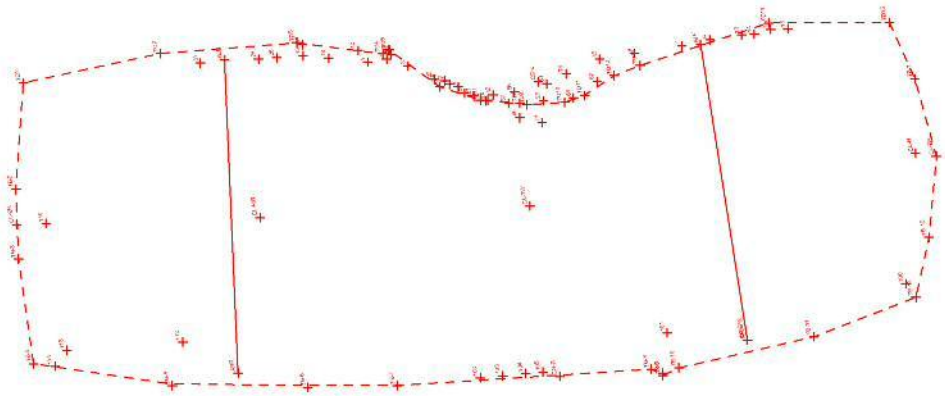
2006 Chevrolet Impala - Crush Profile



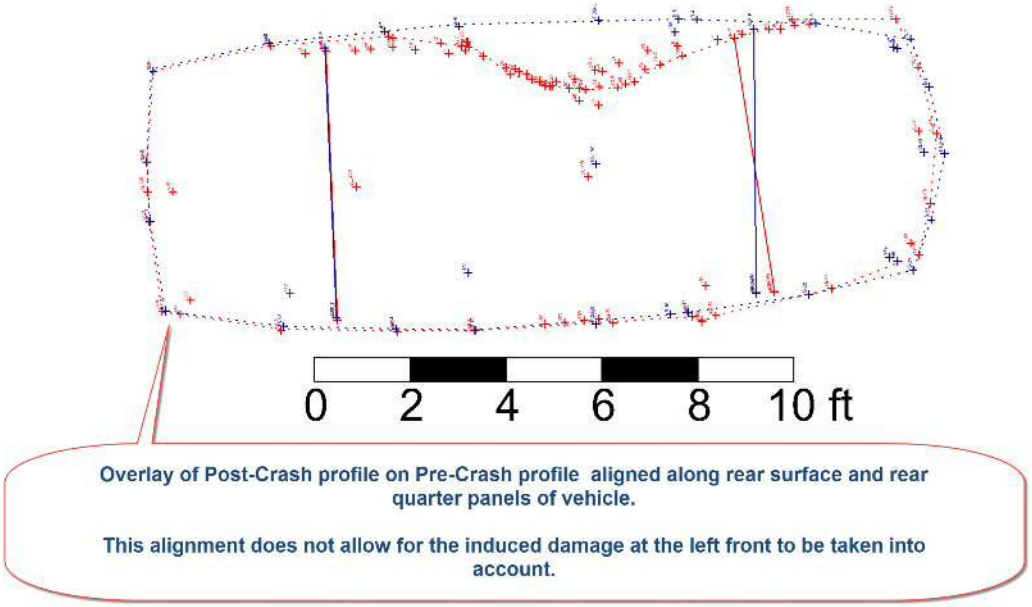
2006 Chevrolet Impala - Crush Profile overlaid on undamaged Profile



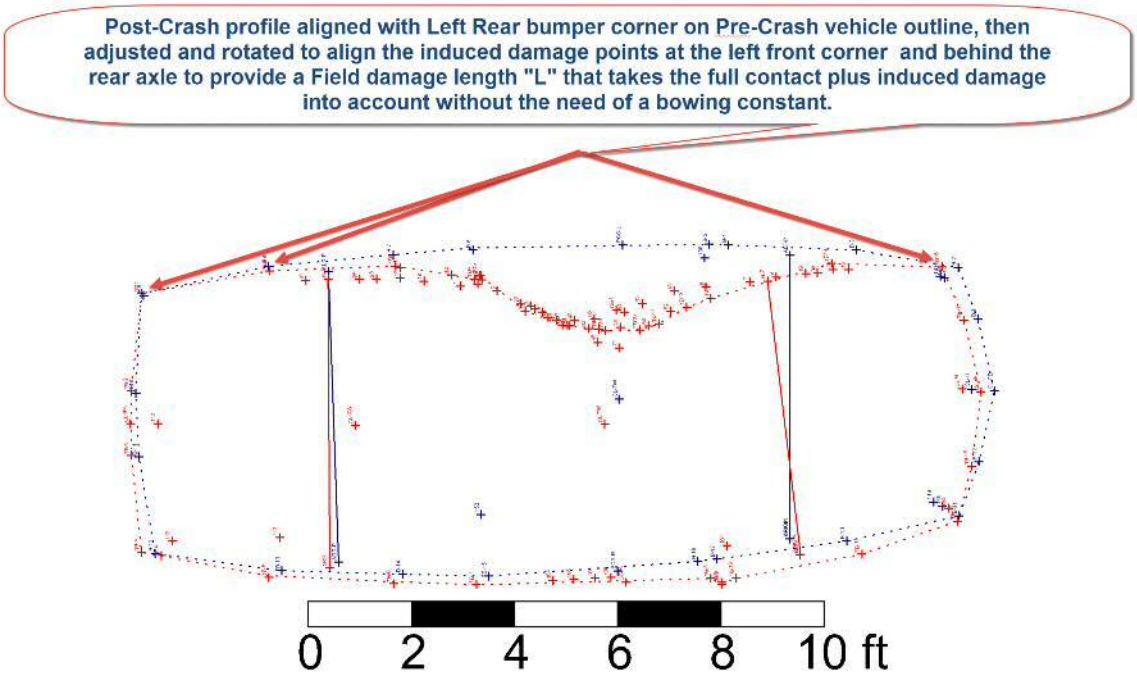
1995 Cadillac Eldorado - Crush Profile



1995 Cadillac Eldorado - Crush Profile overlaid on undamaged Profile - OPTION 1



1995 Cadillac Eldorado - Crush Profile overlaid on undamaged Profile - OPTION 2



CRUSH PROFILES - DISCUSSION

Some of the answers are, perhaps, beginning to take shape at this point.

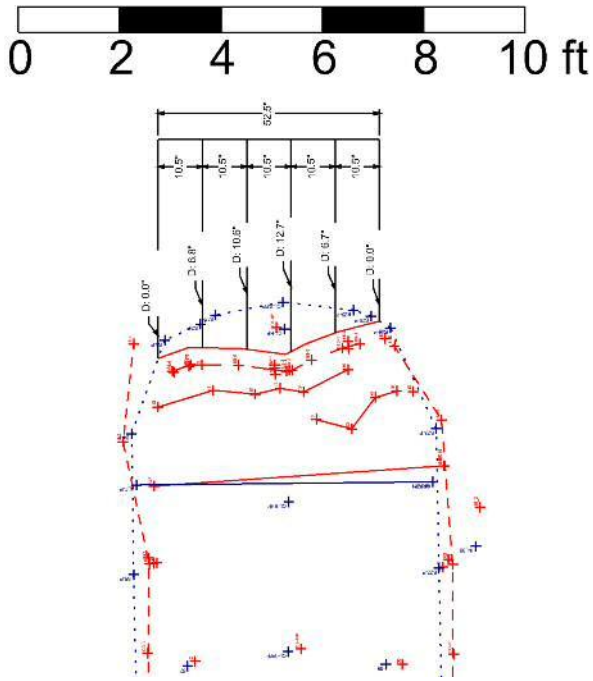
For the Chevrolet Impala (Bullet Vehicle), the most probable points we want to measure to are the bumper support bar, and then subtract out the depth of the energy absorption material. Our studies at various crash tests have found this material varies in depth/thickness between two - six inches, with the most common depth being three - four inches. For the purposes of the measurements for this test, a four-inch depth will be used. Additionally, the line formed by the projected four-inch measurement in front of the bumper support bar will be extended to the undamaged vehicle profile in our determination of the “Field L” Indentation Length for the Bullet Vehicle.

For the Cadillac Eldorado (Target Vehicle), it can be seen that (at least) two possible “Field L” Indentation Lengths could be chosen. We will explore the results of both of those possible lengths in this study.

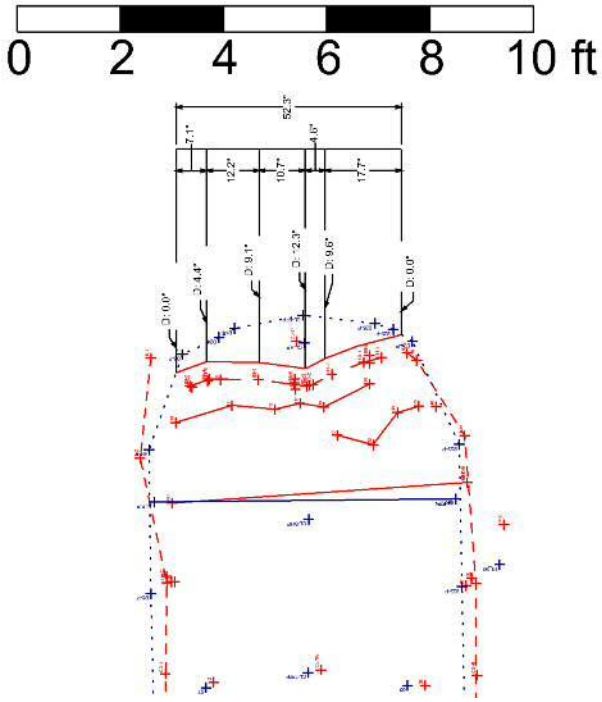
So, the next step is to determine what our Crush measurements are, both for an equally spaced profile as well as for a non-equally spaced profile, and what kind of a “measured” profile each spacing provides.

CRUSH MEASUREMENTS

2006 Chevrolet Impala - Equally Spaced
Average Crush Depth = 7.36 inches
Crush Area ≈ 386 sq. inches

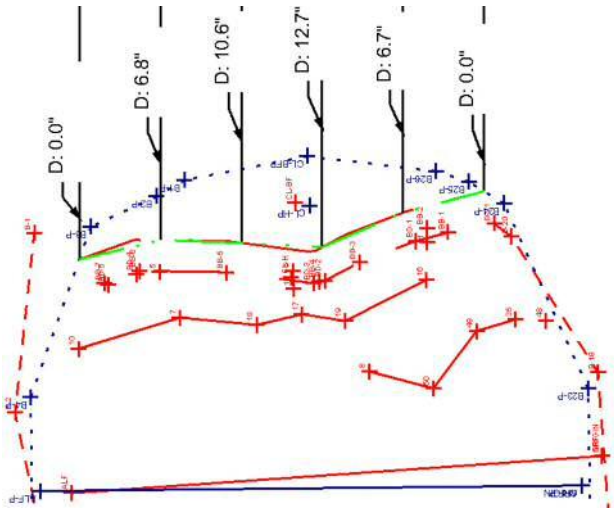


2006 Chevrolet Impala - Non - Equally Spaced
Average Crush Depth = 6.65 inches
Crush Area ≈ 348 sq. inches

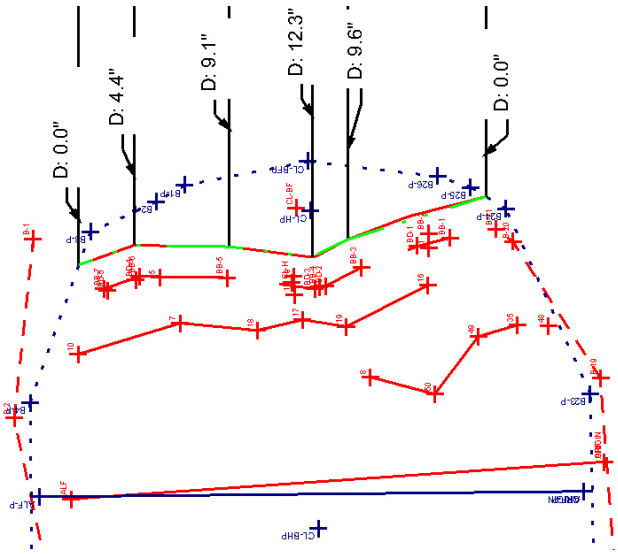


The corresponding MEASURED profiles represented by the GREEN line, can be seen and compared to the "actual" profile below.

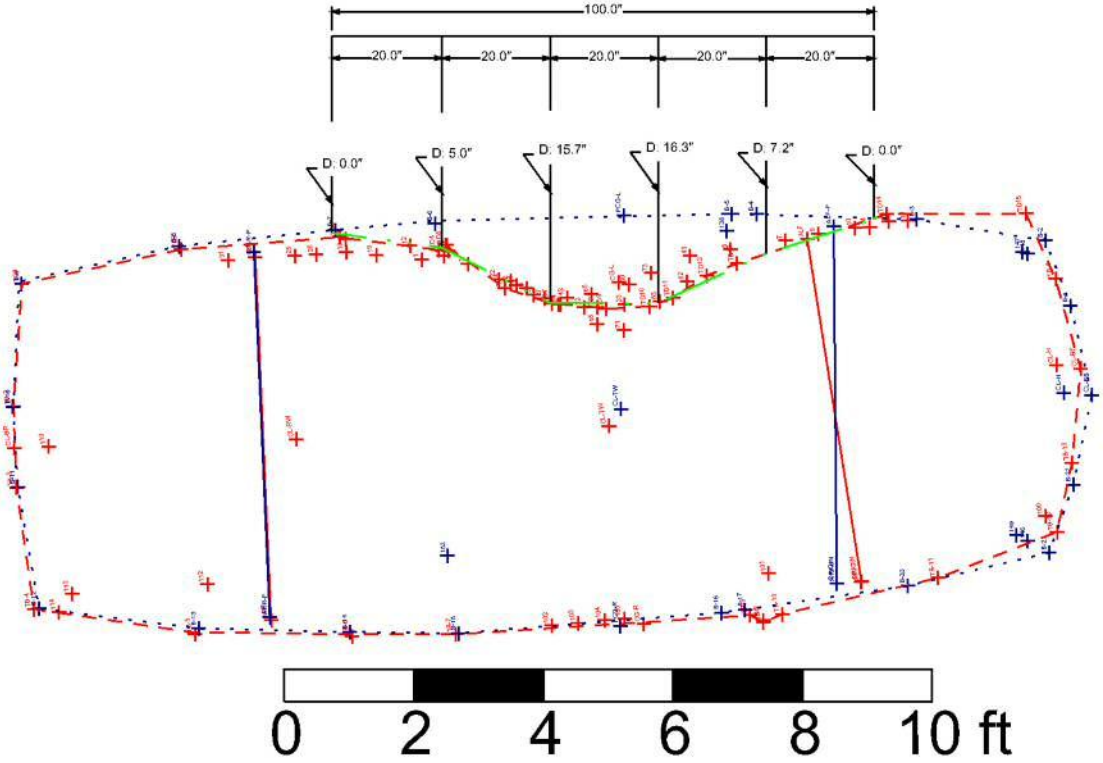
2006 Chevrolet Impala - Equally Spaced



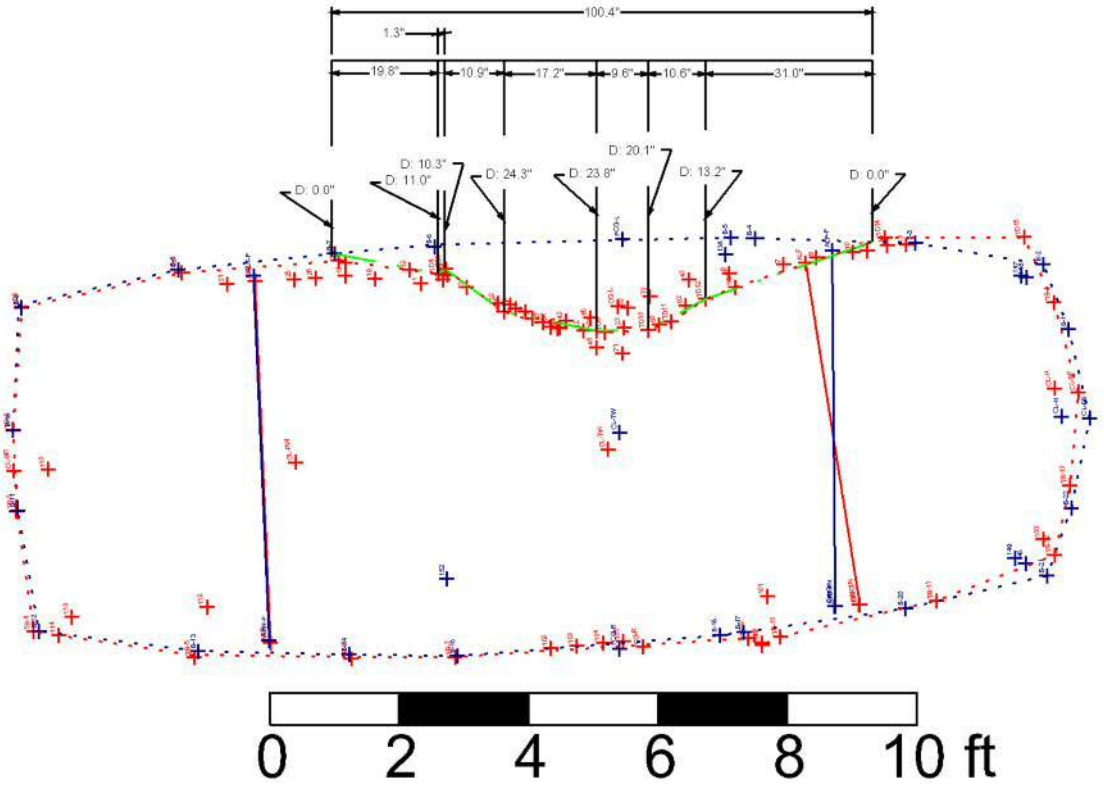
2006 Chevrolet Impala - Non - Equally Spaced



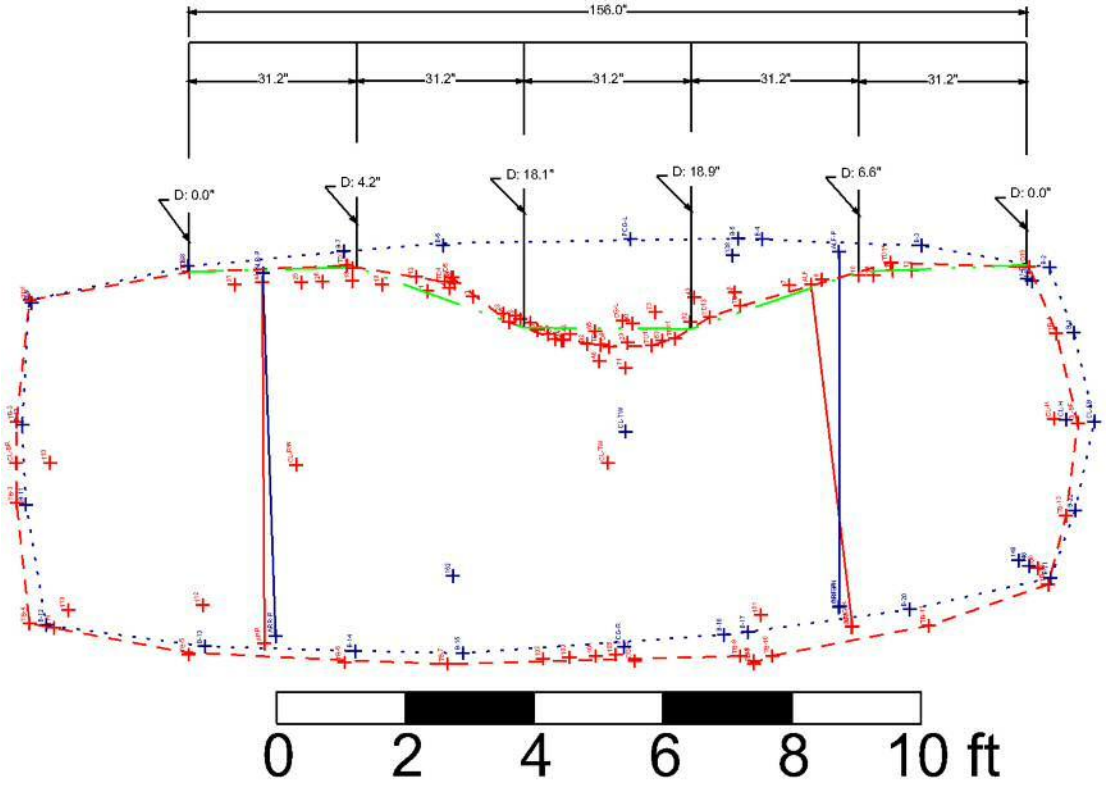
1995 Cadillac Eldorado - Option 1 - Equally Spaced
Average Crush depth = 8.84 inches, Crush Area ≈ 884 square inches



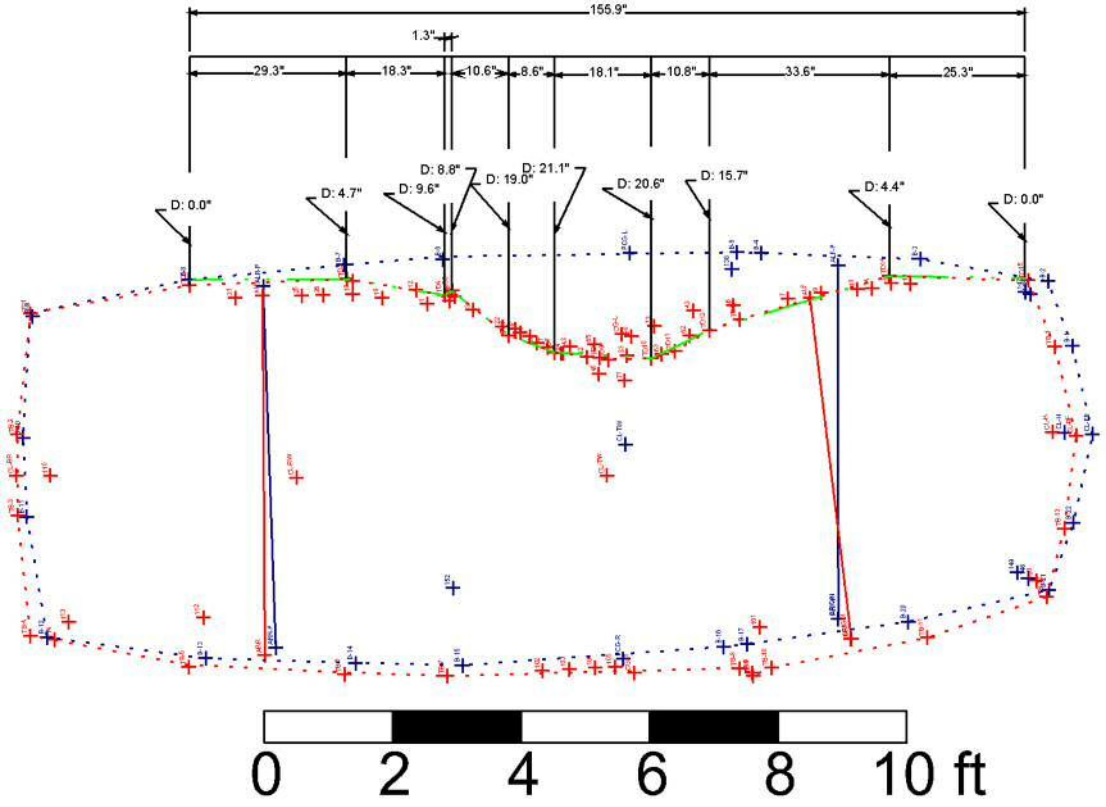
1995 Cadillac Eldorado - Option 1 - NON-Equally Spaced
Average Crush depth = 13.12 inches, Crush Area ≈ 1317 square inches



1995 Cadillac Eldorado - Option 2 - Equally Spaced
Average Crush depth = 9.56 inches, Crush Area ≈ 1491 square inches

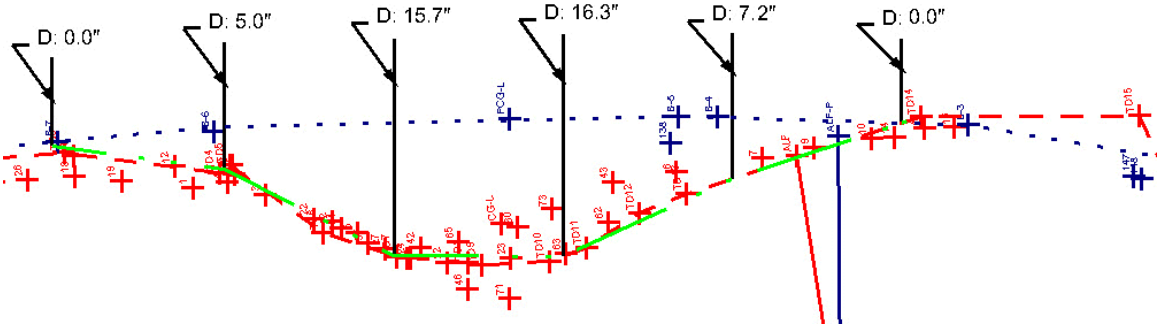


1995 Cadillac Eldorado - Option 2 - NON-Equally Spaced
Average Crush depth = 9.61 inches, Crush Area ≈ 1498 square inches

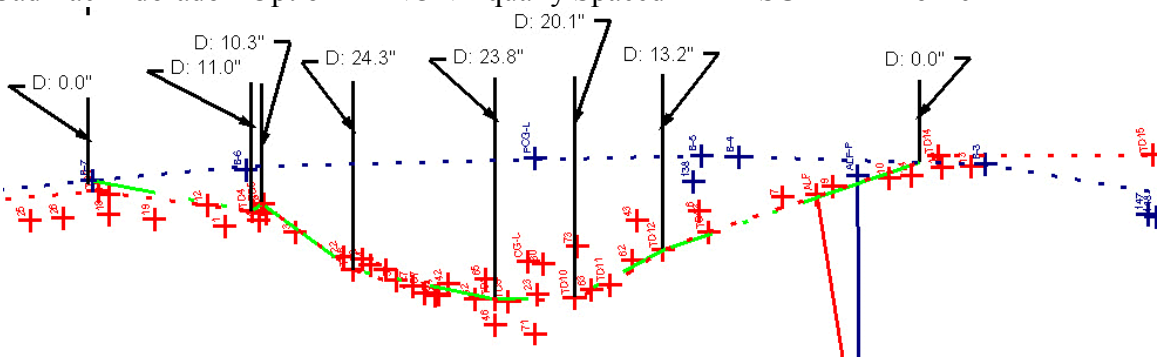


As we did with the Chevrolet Impala, the corresponding MEASURED profiles for the Cadillac Eldorado represented by the GREEN line in each case, can be seen and compared to the "actual" profile below.

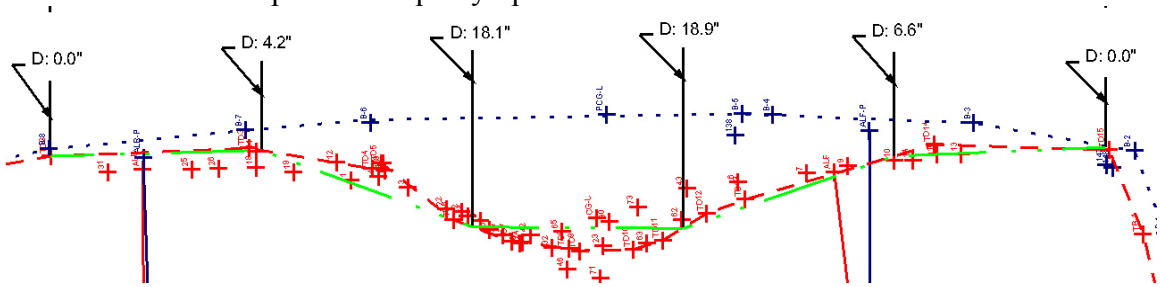
1995 Cadillac Eldorado - Option 1 - Equally Spaced "MEASURED" Profile



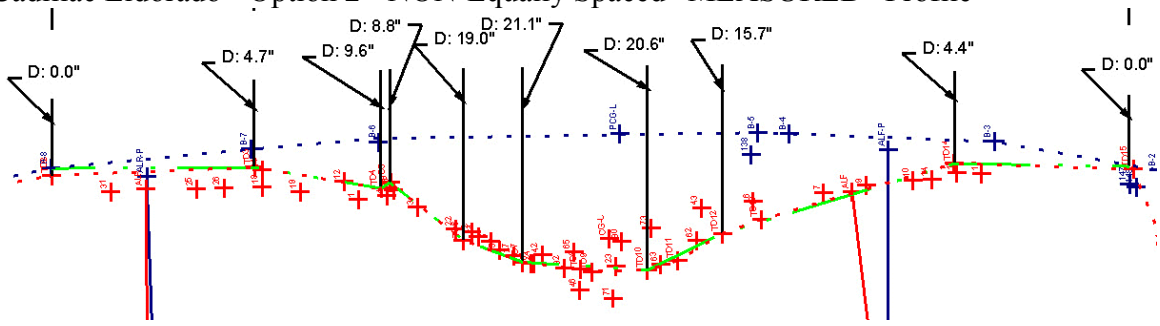
1995 Cadillac Eldorado - Option 1 - NON-Equally Spaced "MEASURED" Profile



1995 Cadillac Eldorado - Option 2 - Equally Spaced "MEASURED" Profile



1995 Cadillac Eldorado - Option 2 - NON-Equally Spaced "MEASURED" Profile



"MEASURED" PROFILE DISCUSSION

It is no surprise that the Non-Equally spaced profile measurements overlay the depicted crush profiles for both vehicles and for both options on the crush length for the Target Vehicle, since the points that are measured are the same points that were picked off from the photographs to create the profile.

One can see some deviation of "Measured" vs. "Actual" profile in the Equally spaced measurements for the Bullet vehicle between measurement points 1 & 2 and between 3 & 4, measuring from the Left (Driver) side toward the Right (Passenger) side. The Non-Equal space measured profile has slightly less crush area (volume) than does the Equal spaced measured profile. This equates to slightly less calculated force for the Bullet vehicle for a given set of A-B stiffness values.

For the Target Vehicle Option 1 it can be seen that the Equally spaced measurements shave off a bit of the crush volume between measurements 1 & 2, 2 & 3, and 3 & 4, with the measurements progressing from the rear toward the front. A reduction in crush volume will lead to a lower calculated speed from the crush to the Target Vehicle. While minor, this reduction of volume is consistent and cumulative.

When we examine the Target Vehicle Option 2 Equally spaced measurements, you can see some rather large discrepancies between the profile depicted from the Equally spaced measurements and the "actual" profile between the 1 & 2, 2 & 3, 4 & 5, and 5 & 6 measurement segments. The effect this has on the speed calculations will be discussed later. In addition to affecting the calculated speed results, profile detail is lost if one only looks at the Equally spaced profile.

FORCE BALANCE SPEED CALCULATIONS

The method we have chosen to test the measurement methods of Equally spaced vs. NON-Equally spaced crush measurements is through the application of a Force balance calculation, and then compare the results to the instrumented results.

The specific Force Balance calculation tool which will be used is the one contained with 4N6XPRT StifCalcs® which is based in part upon the work by Shigemura and Rich contained in the publication "Balancing Collision Forces in Crush/Energy Analysis" available from the IPTM bookstore. Another reason for using this specific tool is that it allows the user to look at the Force Balance results based on the stiffness values from all of the applicable NHTSA Crash Tests for the vehicle you have "the most confidence in."

The term/phrase "most confidence in" is based on a number of factors, including but not limited to, the NUMBER of available NHTSA tests, the quality of the results of those tests, and the quality of the measurements available from the crash being investigated. In this case, the quality of the measurements from the crash being investigated is good, but if you had good measurements for one of the vehicles, but few measurements of questionable quality for the other, the vehicle with good crush measurements is more likely to be the vehicle you have the most confidence in. In the same way, if one of the vehicles has only one or two tests, while the other vehicle has 7-10+ tests, the vehicle with more tests is a candidate for "most confidence in." Which vehicle to use as the "known" or "most confidence in" vehicle is just one more judgement call that the traffic accident investigator needs to make.

In this instance, the Impala is being used as the "Known" vehicle for the calculations because it is a

frontal collision and so has, as a general rule better data quality from the NHTSA Tests, and because there is less to question about the crush to the vehicle in this crash.

Within the NHTSA Crash Test data, there are several factors which must be decided upon as they affect the Stiffness values which are calculated for the "Known" vehicle. The variables which affect the calculations in a frontal test are - No Damage Speed, Crush Depth - Average or Maximum, and Crush Length - Indentation Length vs. Vehicle Width. In order to limit the variables for this discussion, we will be using a 5 mph No Damage speed, the reported Average Crush Depth calculated as a Trapezoidal Average, and the reported Vehicle Width for the Crush Length to be used in the calculations. The Appendices will, however, include the Force Balance results based on reported Maximum Crush from the tests for the "known" vehicle as well.

Within the NHTSA Crash Tests database, there are seven available tests for vehicles with a model year of 2006-2013 of same/similar body type to the 2006 Chevrolet Impala based on manufacturer, model, and year range of minimal changes to the body. The individual test stiffness values and statistical measurement of these tests calculated within the 4N6XPRT StifCalcs program are represented as:

Test Number	Vehicle Info	No Damage Speed (mph)	Average Crush (inch)	Closing Speed (mph)	Vehicle Stiffness A	Vehicle Stiffness B	Width G	Width Kv	Crush Factor
5578	2006 CHEVROLET MONTE CARLO TWO DOOR C...	5.0	26.3	35.0	250.4	57.1	549.0	77.7	18.6
7488	2012 CHEVROLET IMPALA FOUR DOOR SEDAN	5.0	23.9	34.9	282.3	70.7	563.5	96.4	20.4
5468	2006 PONTIAC GRAND PRIX FOUR DOOR SEDAN	5.0	23.5	35.1	283.3	72.5	553.6	98.6	20.9
5547	2006 CHEVROLET IMPALA FOUR DOOR SEDAN	5.0	23.8	35.2	286.3	72.4	565.9	98.5	20.7
5274	2005 BUICK LACROSSE FOUR DOOR SEDAN	5.0	23.4	35.1	287.8	74.2	558.3	100.9	21.1
6052	2007 CHEVROLET IMPALA FOUR DOOR SEDAN	5.0	12.4	24.7	382.5	121.6	601.5	191.1	19.7
7496	2012 CHEVROLET IMPALA FOUR DOOR SEDAN	5.0	6.5	20.0	494.8	229.5	533.3	407.7	24.8
	Average (AVG)				**323.9**	**99.7**	**560.7**	**153.0**	**20.9**
	Minimum (MIN)				**250.4**	**57.1**	**533.3**	**77.7**	**18.6**
	Maximum (MAX)				**494.8**	**229.5**	**601.5**	**407.7**	**24.8**
	Standard Deviation (STDev-sample)				**85.8**	**60.7**	**21.0**	**118.2**	**1.9**
	Number of Tests (n)			7					

These values can then be imported into the Force Balance calculation module contained within the StifCalcs program for further analysis. The basic vehicle data for the "Known" vehicle looks like this -

2006 CHEVROLET IMPALA MSP POLICE PACKAGE - Front Impact

Curb Weight (pounds):	3725
Occupant + Cargo Weight (pounds):	39
Total Weight (pounds):	3764
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	5.0
Energy Crush Depth (inches):	7.36
Damage Length (inches):	52.5
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2670.92

"Known" Stiffness Values

	A	B
Average	323.9	99.7
Minimum	250.4	57.1
Maximum	494.8	229.5
Std. Devation	85.8	60.7

For the analysis, it was assumed that a user would either use equal crush measurement spacing for both

vehicles, or non-equal spacing for both, although one could mix-and-match if they were using their own, non-equally spaced measurements for one vehicle and someone else's equally spaced measurements for the other vehicle, or vice-versa.

The Force Balance was first analyzed with a lever arm of 0 inches for both vehicles and an Angle of the Collision Force off of Normal to the Collision Surface Face of 0 degrees. With these two variables at a value of "0", the calculated forces and speeds will be the minimum values for the given crush profiles. The results for each condition are as follows:

Target "L" = Option 1 ~ 100 inches, Equal Crush Measurement Spacing, No Lever Arm or Angle off of Normal -

Results	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)
Minimum	250.4	57.1	17604.72	18969.79	12.3	12.6	24.5
Avg - 2 Std. Deviations	152.3	-21.7	N/A	N/A	N/A	N/A	N/A
Avg - 1 Std. Deviations	238.1	39.0	13784.93	16655.57	11.5	11.5	22.4
Average	323.9	99.7	27764.42	27581.42	14.8	15.5	30.0
Avg + 1 Std. Deviations	409.7	160.4	41743.91	39372.58	17.7	18.7	36.2
Avg + 2 Std. Deviations	495.5	221.1	55723.40	51316.36	20.2	21.4	41.5
Maximum	494.8	229.5	57327.90	52449.46	20.4	21.6	42.1
Damage Centroid Depth (x) (inches)	4.63				k^2	3290.26	
Damage Centroid Depth (y) (inches)	25.99			Eff. Mass Ratio (gamma)		1.00	
Area of Damage (inches^2):	386.40						

Target "L" = Option 1 ~ 100 inches, Non-Equal Crush Measurement Spacing, No Lever Arm or Angle off of Normal -

Results	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)
Minimum	250.4	57.1	16477.51	16683.88	11.5	13.4	26.0
Avg - 2 Std. Deviations	152.3	-21.7	209.07	N/A	N/A	1.2	2.4
Avg - 1 Std. Deviations	238.1	39.0	13008.32	14872.59	10.9	12.2	23.8
Average	323.9	99.7	25807.57	23961.89	13.8	16.4	31.8
Avg + 1 Std. Deviations	409.7	160.4	38606.81	33913.19	16.4	19.7	38.4
Avg + 2 Std. Deviations	495.5	221.1	51406.06	44016.54	18.7	22.6	44.0
Maximum	494.8	229.5	52848.50	44935.85	18.9	22.9	44.5
Damage Centroid Depth (x) (inches)	4.25				k^2	3290.26	
Damage Centroid Depth (y) (inches)	23.94			Eff. Mass Ratio (gamma)		1.00	
Area of Damage (inches^2):	347.79						

Target "L" = Option 2 ~ 156 inches, Equal Crush Measurement Spacing, No Lever Arm or Angle off of Normal -

Results	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)
Minimum	250.4	57.1	17604.72	18969.79	12.3	13.0	25.4
Avg - 2 Std. Deviations	152.3	-21.7	N/A	N/A	N/A	N/A	N/A
Avg - 1 Std. Deviations	238.1	39.0	13784.93	16655.57	11.5	11.9	23.1
Average	323.9	99.7	27764.42	27581.42	14.8	16.0	31.1
Avg + 1 Std. Deviations	409.7	160.4	41743.91	39372.58	17.7	19.3	37.6
Avg + 2 Std. Deviations	495.5	221.1	55723.40	51316.36	20.2	22.2	43.1
Maximum	494.8	229.5	57327.90	52449.46	20.4	22.5	43.6
Damage Centroid Depth (x) (inches)	4.63				k^2	3290.26	
Damage Centroid Depth (y) (inches)	25.99			Eff. Mass Ratio (gamma)		1.00	
Area of Damage (inches^2):	386.40						

Target “L” = Option 2 ~ 156 inches Non-Equal Crush Measurement Spacing, No Lever Arm or Angle off of Normal -

Results	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)
Minimum	250.4	57.1	16477.51	16683.88	11.5	12.6	24.5
Avg - 2 Std. Deviations	152.3	-21.7	209.07	N/A	N/A	1.0	2.0
Avg - 1 Std. Deviations	238.1	39.0	13008.32	14872.59	10.9	11.5	22.4
Average	323.9	99.7	25807.57	23961.89	13.8	15.4	29.9
Avg + 1 Std. Deviations	409.7	160.4	38606.81	33913.19	16.4	18.5	36.0
Avg + 2 Std. Deviations	495.5	221.1	51406.06	44016.54	18.7	21.2	41.3
Maximum	494.8	229.5	52848.50	44935.85	18.9	21.5	41.8

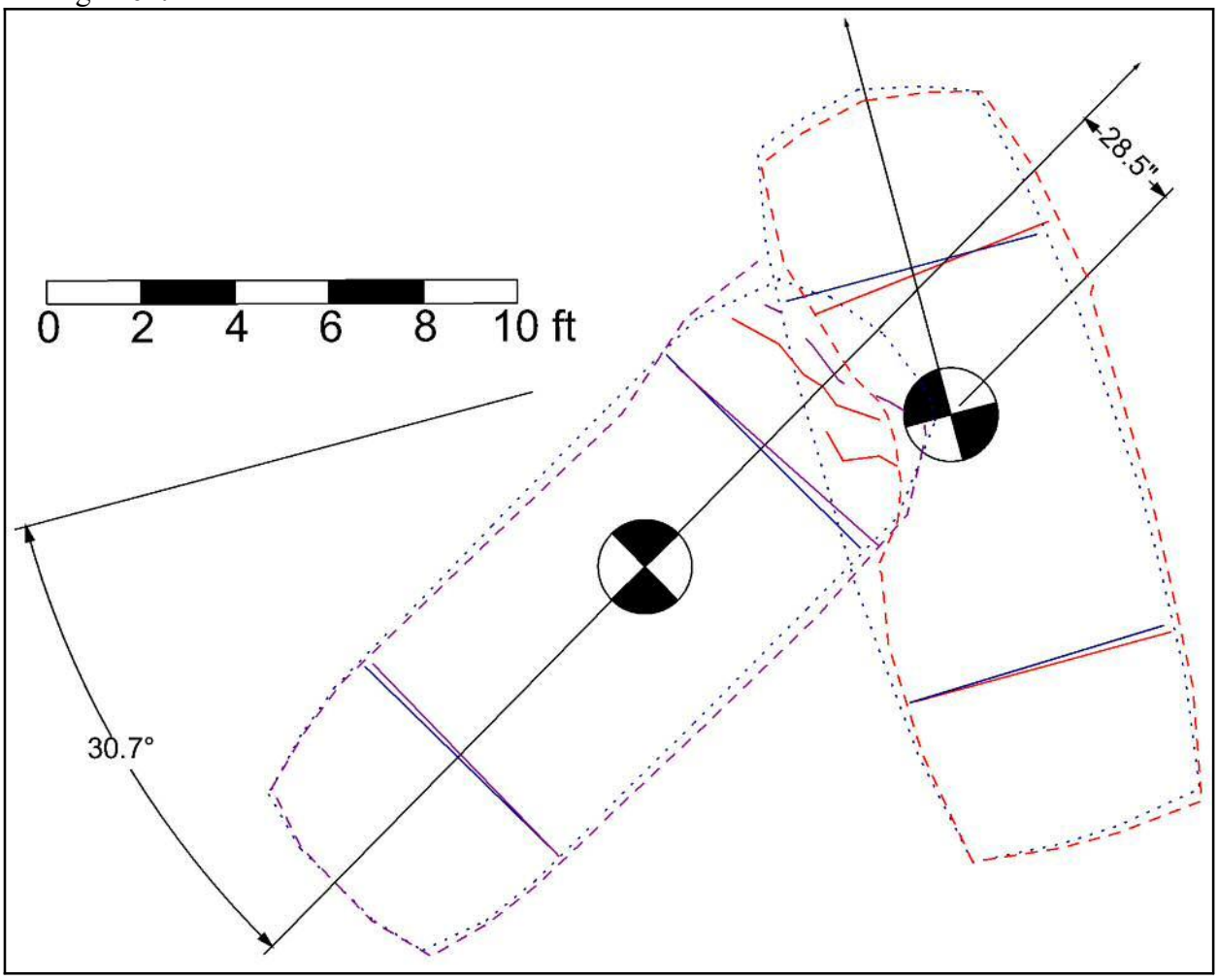
Damage Centroid Depth (x) (inches)	4.25	k^2	3290.26
Damage Centroid Depth (y) (inches)	23.94	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	347.79		

In each case, these results are showing the instrumented closing speed is bracketed by the +1 and +2 Standard Deviation of the Stiffness Values for the Impala. It can also be seen that the AVERAGE stiffness values based on the seven available tests would indicate a closing speed of 29-32 mph. This is just the “first run” before trying to align the vehicles to obtain a Lever Arm and Collision Angle off of Perpendicular.

When we look at some of the Post Crash photographs of the vehicles at rest prior to being separated, we can see there is likely to be both a significant Lever Arm and an Angle component which will serve to increase the calculated speeds.

The post collision alignment finalized on for this study has a Lever Arm on the Target Vehicle of ~28.5 inches and a Collision Angle off of the Perpendicular of ~30 degrees.

POR Alignment



Given this additional data, the Force Balance results are recalculated with the Lever Arm and Angle data input for the Target vehicle.

Target “L” = Option 1 ~ 100 inches, Equal Crush Measurement Spacing, Lever Arm = 28.5 inches, Angle off of Normal = 30 degrees -

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)
Minimum	250.4	57.1	17604.72	18969.79	12.3	12.4	27.0
Avg - 2 Std. Deviations	152.3	-21.7	N/A	N/A	N/A	N/A	N/A
Avg - 1 Std. Deviations	238.1	39.0	13784.93	16655.57	11.5	11.4	24.7
Average	323.9	99.7	27764.42	27581.42	14.8	15.2	33.1
Avg + 1 Std. Deviations	409.7	160.4	41743.91	39372.58	17.7	18.4	39.9
Avg + 2 Std. Deviations	495.5	221.1	55723.40	51316.36	20.2	21.1	45.8
Maximum	494.8	229.5	57327.90	52449.46	20.4	21.3	46.3

Damage Centroid Depth (x) (inches)	4.63	k^2	3290.26
Damage Centroid Depth (y) (inches)	25.99	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	386.40		

Target “L” = Option 1 ~ 100 inches, Non-Equal Crush Measurement Spacing, Lever Arm = 28.5 inches, Angle off of Normal = 30 degrees -

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)
Minimum	250.4	57.1	25607.60	16683.88	11.5	12.2	26.5
Avg - 2 Std. Deviations	152.3	-21.7	N/A	N/A	N/A	N/A	N/A
Avg - 1 Std. Deviations	238.1	39.0	19244.29	14872.59	10.9	11.1	24.1
Average	323.9	99.7	41749.26	23961.89	13.8	15.0	32.5
Avg + 1 Std. Deviations	409.7	160.4	64254.23	33913.19	16.4	18.1	39.3
Avg + 2 Std. Deviations	495.5	221.1	86759.20	44016.54	18.7	20.7	45.0
Maximum	494.8	229.5	89544.77	44935.85	18.9	21.0	45.6

Damage Centroid Depth (x) (inches)	4.25	k^2	3290.26
Damage Centroid Depth (y) (inches)	23.94	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	347.79		

Target “L” = Option 2 ~ 156 inches, Equal Crush Measurement Spacing, Lever Arm = 28.5 inches, Angle off of Normal = 30 degrees -

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)
Minimum	250.4	57.1	17604.72	18969.79	12.3	12.9	28.0
Avg - 2 Std. Deviations	152.3	-21.7	N/A	N/A	N/A	N/A	N/A
Avg - 1 Std. Deviations	238.1	39.0	13784.93	16655.57	11.5	11.7	25.5
Average	323.9	99.7	27764.42	27581.42	14.8	15.8	34.3
Avg + 1 Std. Deviations	409.7	160.4	41743.91	39372.58	17.7	19.1	41.5
Avg + 2 Std. Deviations	495.5	221.1	55723.40	51316.36	20.2	21.9	47.6
Maximum	494.8	229.5	57327.90	52449.46	20.4	22.2	48.2

Damage Centroid Depth (x) (inches)	4.63	k^2	3290.26
Damage Centroid Depth (y) (inches)	25.99	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	386.40		

Target “L” = Option 2 ~ 156 inches, Non-Equal Crush Measurement Spacing, Lever Arm = 28.5 inches, Angle off of Normal = 30 degrees -

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)
Minimum	250.4	57.1	25607.60	16683.88	11.5	11.5	24.9
Avg - 2 Std. Deviations	152.3	-21.7	N/A	N/A	N/A	N/A	N/A
Avg - 1 Std. Deviations	238.1	39.0	19244.29	14872.59	10.9	10.5	22.7
Average	323.9	99.7	41749.26	23961.89	13.8	14.0	30.4
Avg + 1 Std. Deviations	409.7	160.4	64254.23	33913.19	16.4	16.9	36.7
Avg + 2 Std. Deviations	495.5	221.1	86759.20	44016.54	18.7	19.4	42.0
Maximum	494.8	229.5	89544.77	44935.85	18.9	19.6	42.6

Damage Centroid Depth (x) (inches)	4.25	k^2	3290.26
Damage Centroid Depth (y) (inches)	23.94	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	347.79		

When we review the Equally spaced measurement tables, it is seen that the Instrumented Closing Speed of ~ 40 mph is now between the calculated closing speed based on the AVERAGE and +1 Standard Deviation Stiffness Values for the Bullet (Chevrolet Impala) vehicle.

When the Non-Equally spaced measurement tables are reviewed, the Instrumented Closing Speed of ~ 40 mph is still between the calculated closing speed based on the +1 and +2 Standard Deviation Stiffness Values for the Bullet (Chevrolet Impala) vehicle.

This is primarily an effect due to the Non-Equally spaced measurements more closely approximating the actual crush profile for both vehicles.

The Force Balance “tool” uses the Force calculated for the “Known” (more confidence) vehicle and then applies that force (equal but opposite force) to the “Unknown” (less confidence) vehicle to calculate the matching stiffness value pair for the “Unknown” vehicle in that collision. The calculation of A-B stiffness pair values is in large part dependant upon force, average crush depth, and crush length. Likewise, the Force calculated from an A-B pair can to a large extent be evaluated by the Crush Area the stiffness values are applied to.

Since the Equally spaced measurements for the “Known” (Bullet) vehicle result in a somewhat larger area than do the Non-Equally spaced measurements, the Equally spaced measurements will calculate a somewhat greater force for the same A-B stiffness value pair.

For the damage to the Target Vehicle in Option 1, the Average depth for the Equally spaced measurements is 8.84 inches vs. 13.12 inches for the Non-Equally spaced measurements. Given the same force, the shorter average depth will result in higher (stiffer) stiffness values. In the case of this crash, not only is the average crush depth for the Target vehicle significantly greater, but the Force calculated from Non-Equal spacing profile for the Bullet vehicle is somewhat less than for the bullet vehicle Equal spacing profile.

Within the 4N6XPRT StifCalcs Force Balance module, the calculations, the stiffness pair calculated for the “Unknown” vehicle are then used to calculate a damage energy and speed for the “Unknown” vehicle damage. And in the end, a CLOSING speed between the two vehicles is calculated.

In the case of this crash, given that the force for the Bullet vehicle is lower in the Non-Equally spaced profile, together with the significantly larger average crush depth for the Target vehicle in its Non-Equally spaced profile, it is not surprising that the resulting calculated closing speed is lower for a given starting value of A-B values for the Bullet vehicle, even with the larger crush area calculated for the Non-Equal spacing profile.

In the case of Field "L" Option 2 for the Target vehicle, the same explanation holds true for the Bullet vehicle as was given for Option 1. In Option 2, the Equal spacing vs. Non-Equal spacing crush areas are essentially identical. However, the Non-Equal spacing profile has a slightly larger average crush depth, which will again result in lower A-B stiffness values. Lower stiffness values, combined with a lower starting Force from the Bullet vehicle, mean that again the Non-Equal spacing profiles will render, IN THIS CRASH, a lower closing speed. However, this will NOT always be the case.

SUMMARY

Lets review the previously asked questions and see if we now have the answers.

For the Chevrolet Impala -

Q - What is your Field "L"?

A - *The Field "L" chosen for our calculations is an extrapolation of where the Bumper Absorption material would likely intersect the pre-crash vehicle outline. Alternatively, a Field "L" which is the length of the bumper support bar could be chosen, but that would then leave some of the damage to the Impala unaccounted for in the calculations. However, measuring to the right (passenger side) bumper support bar end could be problematical without removing the bumper cover, which brings up the potential for a number of other considerations outside of the realm of this study.*

Q - Where do you measure to on the vehicle to get your crush measurements? Bumper cover? Bumper support bar? Hood? If hood, where on hood?

A - *For the crash in this study, the measurements were taken to the bumper support bar. The bumper cover was not anywhere close to "in place" after the vehicles were separated from each other so that measurements could be taken, so that is not a good candidate for crush measurements. The hood damage "creases" were measured, but not used since it was felt the bumper support bar measurements gave a better representation of the damage, and was less prone to "why" questions. However, the damage on the hood likely could be used if need be to get a conservative estimate of speed from crush. The biggest issue would be determining where the damage crease line locations would be on the pre-crash vehicle in order to get your crush depths. These distances would lend conservative speed estimates in a CRASH 3 analysis because they are not at a level of immediate direct contact, and so do not include the full crush energy expended on the Impala.*

Q - How do you account for the missing material between the bumper support bar and the face of the bumper cover?

A - *Over the last two years we have been examining the dimensions of energy absorption material found between the bumper cover and the bumper support bar. At its maximum depth near the centerline of the vehicle, the material is 3-6 inches in depth, with the*

typical measurement being 3-4 inches. The typical design then has the material taper down in depth so that it is in the neighborhood of 1-3 inches at the outside ends, with the typical measurement being 2-3 inches. For this crash the missing material was accounted for by extending the line of the bumper bar forward a uniform 4 inches and then outwards to intersect with the undamaged pre-crash profile.

Q - Is the "twist" that seems to be present on the right front fender important, or just part of the normal fender shape?

A - *Study of the pre-crash profile indicates the apparent "twist" is more or less the normal curvature of the fender leading from the firewall to the front of the vehicle*.

Q - If you use an equal measurement process, what are you going to lose in the way of crush profile detail?

A - *In the case of THIS crash with THIS vehicle, it seems that little detail is lost*

For the Cadillac Eldorado -

Q - What is your Field "L"?

A - *Two Field "L" measurements were examined. The field "L" which was the result of aligning the pre-crash and post-crash profiles gave the most consistent speed estimates between the two measurement processes.*

Q - Where does it Start?

A - *In the case of Option 1, the Field "L" starts at the forward position of the Rear Wheel Well at the bumper level height. In the case of Option 2, the Field "L" starts at the rear of the Rear Wheel Well at the same bumper level height*.

Q - Stop?

A - *In the case of Option 1, the Field Length "L" terminates at about the position of the front of the front tire. In the case of Option 2, at the left front bumper corner.*

Q - It looks like there may be hinge separation at the "A" pillar - do you average the door sill measurements with the maximum crush measurements? Do you average in the field, or do you measure at the sill line and maximum (~bumper level) crush line and record both depths?

A - *For the purposes of this study, Sill and Maximum Crush Depth Averaging was not used. In part that was due to our experience with applying the Force Balance tool to this type of damage, and our findings that the best results when compared to the instrumented speeds is obtained when the maximum crush depth profile is used for the "Unknown" vehicle. If a standard CRASH 3 analysis is to be used, the averaging method MAY be more appropriate. However, it is our experience that if only the average crush values are recorded in the field, too much profile detail is lost. So IF an averaging method is considered, both the Sill AND the Maximum crush depths should be recorded.*

Q - There appears to be a twist (or bowing) starting at the firewall, is this significant? Do you apply/use a bowing constant?

A - *An examination of the pre-crash and post-crash profiles indicate that the bowing is a definite result of the collision. For this study, a bowing constant was not used as it was felt it was more straightforward to apply a straight line across the driver side damage*

face and measure from that line. The analysis of the speeds calculated from the crush that was measured while accounting for the twist (Option 2) vs ignoring the twist outside of the pre-crash profile (Option 1) resulted in less than a 10% difference in closing speeds between the two methods at the Impala Stiffness value +1 Std Deviation line, as well as less than 10% off of the instrumented bullet vehicle speed.

Q - If you use an equal measurement process, what are you going to lose in the way of crush profile detail?

A - *A close examination of the profile results of the two measurements methods reveals that there is some detail lost by the Equally Spaced measurement process in as compared to the Non-Equally spaced process in Field "L" Option 1, there is significantly more profile detail lost in the Equally Spaced process when applied to Field "L" Option 2. This loss of detail in the Field "L" Option 2 profile would make alignment of the post collision vehicles more difficult if only the six equally spaced depth measurements were recorded in the field.*

Finally, the REAL question(s) are -

Q - Should you worry about the above questions in the field, or back in the office?

A - *It is felt that there are enough questions that come up while out in the field without any additional questions being added that do not have to be. If the vehicles and their damage are documented as any other piece of evidence - i.e. - if it looks like it may be important, document it - and then processed back in the office, it lessens the load on the person(s) in the field, lessens the likelihood that something will be overlooked, and increases the likelihood that you will have answers to questions that you weren't even thinking about out in the field.*

Q - Is Equal Spacing of crush measurements **required** for Speed from Crush Calculations?

A - *It has been illustrated through the application of the Force Balance tool to both crush measurement methods that **NO**, Equal spacing of crush measurements **IS NOT** required for (good) Speed from Crush Calculation results. Whether equal spacing is used for the calculations is based more on your calculation process - Manual, spreadsheet, or "off the shelf" software and what the process/tools require.*

Expert AutoStats®

T2

1995 CADILLAC ELDORADO 2 DOOR COUPE

Horizontal Dimensions

Length	202
Wheelbase	108
Front Bumper to Front Axle	46
Front Bumper to Front Hood	4
Front Bumper to Bot. WindShield	59
Front Bumper to Top Wind Shield	90
Front Bumper to Front Wheel Well	31
Rear Bumper to Rear of Trunk	4
Rear Bumper to Rear Window	28
Rear Bumper to Rear Well	32
Rear Bumper to Rear Axle	48

Depth Dimensions

Width	76
Front Track	61
Rear Track	61

Vertical Dimensions

Height	54
Ground to:	
Front Bumper (Top)	22
Headlight - Center	26
Hood - Top Front	29
Base of Windshield	37
Rear Bumper (Top)	24
Trunk - Top Rear	39
Base of Rear Window	42

Weight Dimensions

Curb Weight 3773

Curb Weight Distribution:

Front = 64 %

Rear = 36 %

Gross Vehicle Weight 4774

Expert AutoStats© Registered to: TUCRRC

Serial Number: 13R-110829AQ...

Appendix 1-1

Appendix 1-2

Expert AutoStats®

B2

2006 CHEVROLET IMPALA MSP POLICE PACKAGE 4 DOOR SEDAN

Horizontal Dimensions

Length	200
Wheelbase	111
Front Bumper to Front Axle	42
Front Bumper to Front Hood	7
Front Bumper to Bot. WindShield	50
Front Bumper to Top Wind Shield	83
Front Bumper to Front Wheel Well	26
Rear Bumper to Rear of Trunk	9
Rear Bumper to Rear Window	26
Rear Bumper to Rear Well	33
Rear Bumper to Rear Axle	47

Depth Dimensions

Width	73
Front Track	61
Rear Track	61

Vertical Dimensions

Height	59
Ground to:	
Front Bumper (Top)	23
Headlight - Center	28
Hood - Top Front	30
Base of Windshield	38
Rear Bumper (Top)	28
Trunk - Top Rear	44
Base of Rear Window	45

Weight Dimensions

Curb Weight	3725

Curb Weight Distribution:

Front = 62 %

Rear = 38 %

Gross Vehicle Weight 4678

Expert AutoStats© Registered to: TUCRRC

Serial Number: 13R-110829AQ...

Appendix 1-3

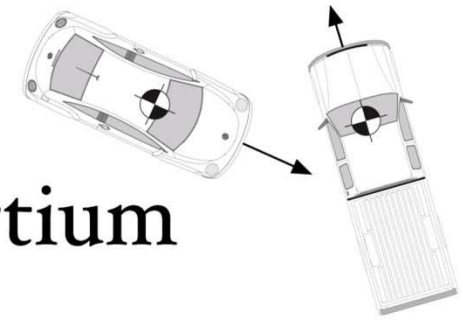
0"
7"
11 3/4"
15"
17"
25 1/2"
24 1/2"
19"
Bumper Cover
11 1/2"
154
Bumper Support Bar
0" @ 4"
46.5"
4"
Corner
Corner
4"
47"
0" @ 4"

Appendix 1-4

IPTM Special Problems 2013
Crash Test Data

THE UNIVERSITY of TULSA

Crash Reconstruction Research Consortium



Appendix 2-1

Introduction and Overview

- Jeremy Daily, Ph.D., P.E.
  - Associate Professor of Mechanical Engineering
  - Director of the Crash Reconstruction Research Consortium
- Jose Corcega
  - Graduate Student of Mechanical Engineering
  - Data acquisition with eDAQ system
- Andrew Kongs
  - Engineering Research Technician
  - All things electrical (Power Distribution, Brake Signals, and Wireless distribution system).

Appendix 2-2

THE UNIVERSITY of TULSA

- James Johnson
  - Ph.D. Student in Computer Science
  - VBox Data and Heavy Truck Digital Forensics
- Amila Perera
  - Graduate Student in Engineering Physics
  - Steering measurements and HVE
- Richard Ruth,
  - IPTM Lead EDR Trainer
  - Crash data from factory and ride along EDRs

Appendix 2-3

THE UNIVERSITY of TULSA

- Alison Maskus, Electrical Engineering Graduate Student
- Skippy (and Paco)
- Olly, the dog (named after a computer program)

Appendix 2-4

White Impala into White Cadillac

CRASH TEST 2

Appendix 2-5

Vehicle Descriptions

2006 Chevrolet Impala

- Bullet Vehicle
- 2G1WS551269435709

1995 Cadillac Eldorado

- Target Vehcile
- 1G6EL12Y05U601252

Appendix 2-6

VEHICLE WEIGHT SUMMARY CRASH 2

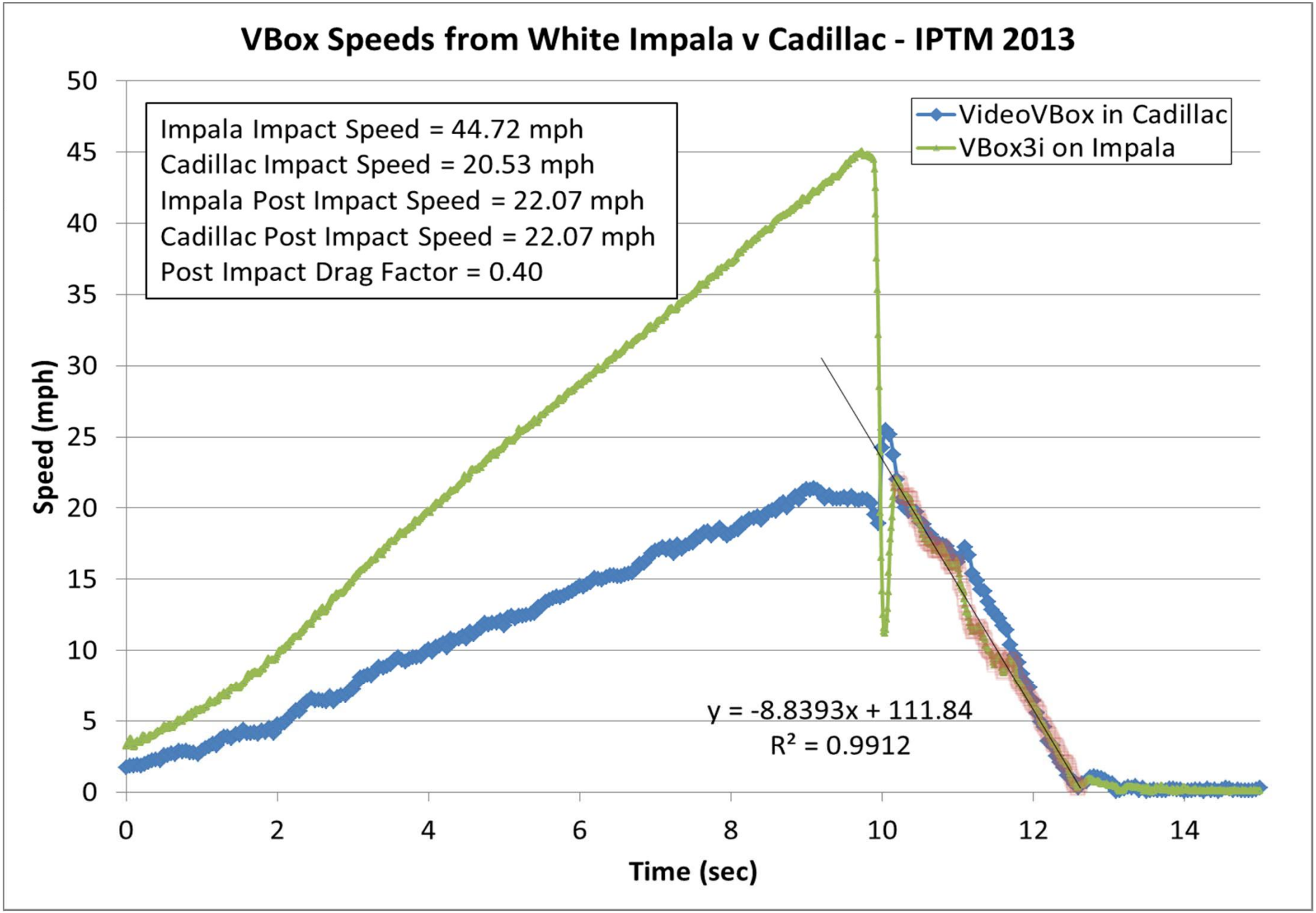
Measurement	2006 Chevrolet Impala	Cadillac El Dorado
Right Front [lb]	1250	1203
Left Front [lb]	1132	1268
Right Rear [lb]	683	745
Left Rear [lb]	699	675
Total [lb]	3764	3891
Track width [in]	61	61
Wheel base [in]	111	108
Center of mass (X,Y) [inch]	(70.7,20.5)	(77.3,37.3)

Appendix 2-7

CRASH 2 SUMMARY

Measurement	2006 Chevrolet Impala	Cadillac El Dorado
Impact Speed [mph]	40.9	19.49
Impact Angle [deg (N)]	359.6	268.6
Delta V in X [mph]	-22.26	-
Delta V in Y [mph]	-9.67	-
Crash Pulse Time [ms]	150	150
Peak Angular Velocity [deg/sec]	-147	-
Post impact Speed [mph]	28.5	23.23

Appendix 2-8


VBox Speeds from White Impala v Cadillac - IPTM 2013
Impala Impact Speed = 44.72 mph
Cadillac Impact Speed = 20.53 mph
Impala Post Impact Speed = 22.07 mph
Cadillac Post Impact Speed = 22.07 mph
Post Impact Drag Factor = 0.40
VideoVBox in Cadillac
VBox3i on Impala
y = -8.8393x + 111.84
R² = 0.9912
Speed (mph)
Time (sec)
0
5
10
15
20
25
30
35
40
45
50
0
2
4
6
8
10
12
14

Appendix 2-9

Computing Drag Factor

- Given a time history of speed in mph
  - Determine the slope of the graph using the Trendline feature in Excel
  - The units of the slope are mph/s
  - Convert mph to ft/s by multiplying by 1.466
  - Divide by 32.2 to get g's
  - Example:

$$-8.8393 * \frac{1.466}{32.2} = 0.4026$$

Appendix 2-10

APPENDIX 3

NHTSA Tests for
AVERAGE CRUSH
Stiffness Value Determination

Available Test Results
Front Impact Test Summary

Report Filter Settings

Year Range: 2006 - 2013
Make: CHEVROLET
Model: IMPALA

Test Number	Vehicle Info	No Damage Speed (mph)	Average Crush (inch)	Closing Speed (mph)	Vehicle Stiffness A	Vehicle Stiffness B	Vehicle Width Values G	Vehicle Width Values Kv	Crush Factor
5578	2006 CHEVROLET MONTE CARLO TWO DOOR C...	5.0	26.3	35.0	250.4	57.1	549.0	77.7	18.6
7488	2012 CHEVROLET IMPALA FOUR DOOR SEDAN	5.0	23.9	34.9	282.3	70.7	563.5	96.4	20.4
5468	2006 PONTIAC GRAND PRIX FOUR DOOR SEDAN	5.0	23.5	35.1	283.3	72.5	553.6	98.6	20.9
5547	2006 CHEVROLET IMPALA FOUR DOOR SEDAN	5.0	23.8	35.2	286.3	72.4	565.9	98.5	20.7
5274	2005 BUICK LACROSSE FOUR DOOR SEDAN	5.0	23.4	35.1	287.8	74.2	558.3	100.9	21.1
6052	2007 CHEVROLET IMPALA FOUR DOOR SEDAN	5.0	12.4	24.7	382.5	121.6	601.5	191.1	19.7
7496	2012 CHEVROLET IMPALA FOUR DOOR SEDAN	5.0	6.5	20.0	494.8	229.5	533.3	407.7	24.8
	Average (AVG)				**323.9**	**99.7**	**560.7**	**153.0**	**20.9**
	Minimum (MIN)				**250.4**	**57.1**	**533.3**	**77.7**	**18.6**
	Maximum (MAX)				**494.8**	**229.5**	**601.5**	**407.7**	**24.8**
	Standard Deviation (STDev-sample)				**85.8**	**60.7**	**21.0**	**118.2**	**1.9**
	Number of Tests (n)			**7**					

APPENDIX 3

Crush Length = OPTION 1

Impala Stiffness Values from NHTSA Tests = AVERAGE CRUSH

Crush Measurement Spacing = EQUAL

Lever Arm and Angle = NO

Page 1 = "KNOWN" = Bullet
Page 2 = "UNKNOWN" = Target
Page 3 = The two pages combined onto 1

2006 CHEVROLET IMPALA MSP POLICE PACKAGE - Front Impact

Curb Weight (pounds):	3725
Occupant + Cargo Weight (pounds):	39
Total Weight (pounds):	3764
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	5.0
Energy Crush Depth (inches):	7.36
Damage Length (inches):	52.5
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2670.92

"Known" Stiffness Values

	A	B
Average	323.9	99.7
Minimum	250.4	57.1
Maximum	494.8	229.5
Std. Devation	85.8	60.7

		Equal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00	10.50	35.18	2.23	78.56	7.00	246.23
C2 (inches)	6.70	10.50	101.85	5.00	509.72	16.29	1659.26
C3 (inches)	12.70	10.50	122.33	5.84	714.47	26.09	3191.74
C4 (inches)	10.60	10.50	91.35	4.42	403.69	36.37	3322.20
C5 (inches)	6.80	10.50	35.70	2.27	80.92	45.50	1624.35
C6 (inches)	0.00						
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 7.36

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)
Minimum	250.4	57.1	17604.72	18969.79	12.3	12.6	24.5
Avg - 2 Std. Deviations	152.3	-21.7	N/A	N/A	N/A	N/A	N/A
Avg - 1 Std. Deviations	238.1	39.0	13784.93	16655.57	11.5	11.5	22.4
Average	323.9	99.7	27764.42	27581.42	14.8	15.5	30.0
Avg + 1 Std. Deviations	409.7	160.4	41743.91	39372.58	17.7	18.7	36.2
Avg + 2 Std. Deviations	495.5	221.1	55723.40	51316.36	20.2	21.4	41.5
Maximum	494.8	229.5	57327.90	52449.46	20.4	21.6	42.1

Damage Centroid Depth (x) (inches)	4.63	k^2	3290.26
Damage Centroid Depth (y) (inches)	25.99	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	386.40		

1995 CADILLAC ELDORADO - Side Impact

Curb Weight (pounds):	3773
Occupant + Cargo Weight (pounds):	218
Total Weight (pounds):	3991
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	2.0
Energy Crush Depth (inches):	8.84
Damage Length (inches):	100.0
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2904.73

		Equal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00	20.00	50.00	1.67	83.33	13.33	666.67
C2 (inches)	5.00	20.00	207.00	5.64	1166.63	31.72	6566.67
C3 (inches)	15.70	20.00	320.00	8.00	2560.30	50.06	16020.00
C4 (inches)	16.30	20.00	235.00	6.17	1449.63	68.71	16146.67
C5 (inches)	7.20	20.00	72.00	2.40	172.80	86.67	6240.00
C6 (inches)	0.00						
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 8.84

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	bsub1
Minimum	64.6	32.5	17604.72	20015.11	12.3	11.9	17.7
Avg - 2 Std. Deviations	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Avg - 1 Std. Deviations	56.4	24.8	13784.93	15919.06	10.9	10.9	15.5
Average	82.8	53.5	27764.42	30829.98	15.2	14.6	22.7
Avg + 1 Std. Deviations	103.0	82.8	41743.91	45603.03	18.5	17.6	28.3
Avg + 2 Std. Deviations	120.0	112.5	55723.40	60304.75	21.3	20.2	33.0
Maximum	121.9	115.9	57327.90	61988.91	21.6	20.4	33.5

Damage Centroid Depth (x) (inches)	6.15	k^2	3374.76
Damage Centroid Depth (y) (inches)	51.63	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	884.00		

2006 CHEVROLET IMPALA MSP POLICE PACKAGE - Front Impact

Curb Weight (pounds):	3725
Occupant + Cargo Weight (pounds):	39
Total Weight (pounds):	3764
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	5.0
Energy Crush Depth (inches):	7.36
Damage Length (inches):	52.5
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2670.92

"Known" Stiffness Values

	A	B
Average	323.9	99.7
Minimum	250.4	57.1
Maximum	494.8	229.5
Std. Devation	85.8	60.7

		Equal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00						
C2 (inches)	6.70	10.50	35.18	2.23	78.56	7.00	246.23
C3 (inches)	12.70	10.50	101.85	5.00	509.72	16.29	1659.26
C4 (inches)	10.60	10.50	122.33	5.84	714.47	26.09	3191.74
C5 (inches)	6.80	10.50	91.35	4.42	403.69	36.37	3322.20
C6 (inches)	0.00	10.50	35.70	2.27	80.92	45.50	1624.35
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 7.36

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)
Minimum	250.4	57.1	17604.72	18969.79	12.3	12.6	24.5
Avg - 2 Std. Deviations	152.3	-21.7	N/A	N/A	N/A	N/A	N/A
Avg - 1 Std. Deviations	238.1	39.0	13784.93	16655.57	11.5	11.5	22.4
Average	323.9	99.7	27764.42	27581.42	14.8	15.5	30.0
Avg + 1 Std. Deviations	409.7	160.4	41743.91	39372.58	17.7	18.7	36.2
Avg + 2 Std. Deviations	495.5	221.1	55723.40	51316.36	20.2	21.4	41.5
Maximum	494.8	229.5	57327.90	52449.46	20.4	21.6	42.1

Damage Centroid Depth (x) (inches)	4.63	k^2	3290.26
Damage Centroid Depth (y) (inches)	25.99	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	386.40		

1995 CADILLAC ELDORADO - Side Impact

Curb Weight (pounds):	3773
Occupant + Cargo Weight (pounds):	218
Total Weight (pounds):	3991
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	2.0
Energy Crush Depth (inches):	8.84
Damage Length (inches):	100.0
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2904.73

		Equal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00						
C2 (inches)	5.00	20.00	50.00	1.67	83.33	13.33	666.67
C3 (inches)	15.70	20.00	207.00	5.64	1166.63	31.72	6566.67
C4 (inches)	16.30	20.00	320.00	8.00	2560.30	50.06	16020.00
C5 (inches)	7.20	20.00	235.00	6.17	1449.63	68.71	16146.67
C6 (inches)	0.00	20.00	72.00	2.40	172.80	86.67	6240.00
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 8.84

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	bsub1
Minimum	64.6	32.5	17604.72	20015.11	12.3	11.9	17.7
Avg - 2 Std. Deviations	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Avg - 1 Std. Deviations	56.4	24.8	13784.93	15919.06	10.9	10.9	15.5
Average	82.8	53.5	27764.42	30829.98	15.2	14.6	22.7
Avg + 1 Std. Deviations	103.0	82.8	41743.91	45603.03	18.5	17.6	28.3
Avg + 2 Std. Deviations	120.0	112.5	55723.40	60304.75	21.3	20.2	33.0
Maximum	121.9	115.9	57327.90	61988.91	21.6	20.4	33.5

Damage Centroid Depth (x) (inches)	6.15	k^2	3374.76
Damage Centroid Depth (y) (inches)	51.63	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	884.00		

APPENDIX 3

Crush Length = OPTION 1

Impala Stiffness Values from NHTSA Tests = AVERAGE CRUSH

Crush Measurement Spacing = NON-EQUAL

Lever Arm and Angle = NO

Page 1 = "KNOWN" = Bullet
Page 2 = "UNKNOWN" = Target
Page 3 = The two pages combined onto 1

2006 CHEVROLET IMPALA MSP POLICE PACKAGE - Front Impact

Curb Weight (pounds):	3725
Occupant + Cargo Weight (pounds):	39
Total Weight (pounds):	3764
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	5.0
Energy Crush Depth (inches):	6.65
Damage Length (inches):	52.3
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2670.92

"Known" Stiffness Values

	A	B
Average	323.9	99.7
Minimum	250.4	57.1
Maximum	494.8	229.5
Std. Devation	85.8	60.7

		Unequal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00						
C2 (inches)	9.60	17.70	84.96	3.20	271.87	11.80	1002.53
C3 (inches)	12.30	4.60	50.37	5.50	277.17	6.99	352.31
C4 (inches)	9.10	10.70	114.49	5.39	617.09	26.48	3032.08
C5 (inches)	4.40	12.20	82.35	3.51	289.16	41.99	3458.05
C6 (inches)	0.00	7.10	15.62	1.47	22.91	30.77	480.58
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 6.65

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)
Minimum	250.4	57.1	16477.51	16683.88	11.5	13.4	26.0
Avg - 2 Std. Deviations	152.3	-21.7	209.07	N/A	N/A	1.2	2.4
Avg - 1 Std. Deviations	238.1	39.0	13008.32	14872.59	10.9	12.2	23.8
Average	323.9	99.7	25807.57	23961.89	13.8	16.4	31.8
Avg + 1 Std. Deviations	409.7	160.4	38606.81	33913.19	16.4	19.7	38.4
Avg + 2 Std. Deviations	495.5	221.1	51406.06	44016.54	18.7	22.6	44.0
Maximum	494.8	229.5	52848.50	44935.85	18.9	22.9	44.5

Damage Centroid Depth (x) (inches)	4.25	k^2	3290.26
Damage Centroid Depth (y) (inches)	23.94	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	347.79		

1995 CADILLAC ELDORADO - Side Impact

Curb Weight (pounds):	3773
Occupant + Cargo Weight (pounds):	218
Total Weight (pounds):	3991
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	2.0
Energy Crush Depth (inches):	13.12
Damage Length (inches):	100.4
Crush Profile Measurements:	8

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2904.73

		Unequal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00	19.80	108.90	3.67	399.30	13.20	1437.48
C2 (inches)	11.00	1.30	13.85	5.33	73.75	1.94	26.90
C3 (inches)	10.30	10.90	188.57	9.12	1720.15	27.99	5277.14
C4 (inches)	24.30	17.20	413.66	12.03	4974.44	60.17	24890.01
C5 (inches)	23.80	9.60	210.72	11.00	2318.13	43.07	9074.69
C6 (inches)	20.10	10.60	176.49	8.44	1490.31	57.93	10224.76
C7 (inches)	13.20	31.00	204.60	4.40	900.24	196.33	40169.80
C8 (inches)	0.00						
C9 (inches)							
C10 (inches)							

Average Crush (inches): 13.12

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	bsub1
Minimum	51.8	21.1	16477.51	27072.24	14.3	12.6	14.3
Avg - 2 Std. Deviations	3.1	0.1	209.07	955.87	2.7	1.2	0.9
Avg - 1 Std. Deviations	45.6	16.3	13008.32	21644.05	12.8	11.5	12.6
Average	66.0	34.2	25807.57	41578.13	17.7	15.4	18.2
Avg + 1 Std. Deviations	81.8	52.4	38606.81	61351.14	21.5	18.6	22.6
Avg + 2 Std. Deviations	95.1	70.8	51406.06	81040.09	24.7	21.3	26.2
Maximum	96.4	72.9	52848.50	83255.22	25.0	21.6	26.6

Damage Centroid Depth (x) (inches)	9.02	k^2	3374.76
Damage Centroid Depth (y) (inches)	69.18	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	1316.79		

2006 CHEVROLET IMPALA MSP POLICE PACKAGE - Front Impact

Curb Weight (pounds):	3725
Occupant + Cargo Weight (pounds):	39
Total Weight (pounds):	3764
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	5.0
Energy Crush Depth (inches):	6.65
Damage Length (inches):	52.3
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2670.92

"Known" Stiffness Values

	A	B
Average	323.9	99.7
Minimum	250.4	57.1
Maximum	494.8	229.5
Std. Devation	85.8	60.7

		Unequal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00						
C2 (inches)	9.60	17.70	84.96	3.20	271.87	11.80	1002.53
C3 (inches)	12.30	4.60	50.37	5.50	277.17	6.99	352.31
C4 (inches)	9.10	10.70	114.49	5.39	617.09	26.48	3032.08
C5 (inches)	4.40	12.20	82.35	3.51	289.16	41.99	3458.05
C6 (inches)	0.00	7.10	15.62	1.47	22.91	30.77	480.58
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 6.65

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)
Minimum	250.4	57.1	16477.51	16683.88	11.5	13.4	26.0
Avg - 2 Std. Deviations	152.3	-21.7	209.07	N/A	N/A	1.2	2.4
Avg - 1 Std. Deviations	238.1	39.0	13008.32	14872.59	10.9	12.2	23.8
Average	323.9	99.7	25807.57	23961.89	13.8	16.4	31.8
Avg + 1 Std. Deviations	409.7	160.4	38606.81	33913.19	16.4	19.7	38.4
Avg + 2 Std. Deviations	495.5	221.1	51406.06	44016.54	18.7	22.6	44.0
Maximum	494.8	229.5	52848.50	44935.85	18.9	22.9	44.5

Damage Centroid Depth (x) (inches)	4.25	k^2	3290.26
Damage Centroid Depth (y) (inches)	23.94	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	347.79		

1995 CADILLAC ELDORADO - Side Impact

Curb Weight (pounds):	3773
Occupant + Cargo Weight (pounds):	218
Total Weight (pounds):	3991
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	2.0
Energy Crush Depth (inches):	13.12
Damage Length (inches):	100.4
Crush Profile Measurements:	8

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2904.73

		Unequal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00						
C2 (inches)	11.00	19.80	108.90	3.67	399.30	13.20	1437.48
C3 (inches)	10.30	1.30	13.85	5.33	73.75	1.94	26.90
C4 (inches)	24.30	10.90	188.57	9.12	1720.15	27.99	5277.14
C5 (inches)	23.80	17.20	413.66	12.03	4974.44	60.17	24890.01
C6 (inches)	20.10	9.60	210.72	11.00	2318.13	43.07	9074.69
C7 (inches)	13.20	10.60	176.49	8.44	1490.31	57.93	10224.76
C8 (inches)	0.00	31.00	204.60	4.40	900.24	196.33	40169.80
C9 (inches)							
C10 (inches)							

Average Crush (inches): 13.12

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	bsub1
Minimum	51.8	21.1	16477.51	27072.24	14.3	12.6	14.3
Avg - 2 Std. Deviations	3.1	0.1	209.07	955.87	2.7	1.2	0.9
Avg - 1 Std. Deviations	45.6	16.3	13008.32	21644.05	12.8	11.5	12.6
Average	66.0	34.2	25807.57	41578.13	17.7	15.4	18.2
Avg + 1 Std. Deviations	81.8	52.4	38606.81	61351.14	21.5	18.6	22.6
Avg + 2 Std. Deviations	95.1	70.8	51406.06	81040.09	24.7	21.3	26.2
Maximum	96.4	72.9	52848.50	83255.22	25.0	21.6	26.6

Damage Centroid Depth (x) (inches)	9.02	k^2	3374.76
Damage Centroid Depth (y) (inches)	69.18	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	1316.79		

APPENDIX 3

Crush Length = OPTION 2

Impala Stiffness Values from NHTSA Tests = AVERAGE CRUSH

Crush Measurement Spacing = EQUAL

Lever Arm and Angle = NO

Page 1 = "KNOWN" = Bullet
Page 2 = "UNKNOWN" = Target
Page 3 = The two pages combined onto 1

2006 CHEVROLET IMPALA MSP POLICE PACKAGE - Front Impact

Curb Weight (pounds):	3725
Occupant + Cargo Weight (pounds):	39
Total Weight (pounds):	3764
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	5.0
Energy Crush Depth (inches):	7.36
Damage Length (inches):	52.5
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2670.92

"Known" Stiffness Values

	A	B
Average	323.9	99.7
Minimum	250.4	57.1
Maximum	494.8	229.5
Std. Devation	85.8	60.7

		Equal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00	10.50	35.18	2.23	78.56	7.00	246.23
C2 (inches)	6.70	10.50	101.85	5.00	509.72	16.29	1659.26
C3 (inches)	12.70	10.50	122.33	5.84	714.47	26.09	3191.74
C4 (inches)	10.60	10.50	91.35	4.42	403.69	36.37	3322.20
C5 (inches)	6.80	10.50	35.70	2.27	80.92	45.50	1624.35
C6 (inches)	0.00						
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 7.36

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)
Minimum	250.4	57.1	17604.72	18969.79	12.3	13.0	25.4
Avg - 2 Std. Deviations	152.3	-21.7	N/A	N/A	N/A	N/A	N/A
Avg - 1 Std. Deviations	238.1	39.0	13784.93	16655.57	11.5	11.9	23.1
Average	323.9	99.7	27764.42	27581.42	14.8	16.0	31.1
Avg + 1 Std. Deviations	409.7	160.4	41743.91	39372.58	17.7	19.3	37.6
Avg + 2 Std. Deviations	495.5	221.1	55723.40	51316.36	20.2	22.2	43.1
Maximum	494.8	229.5	57327.90	52449.46	20.4	22.5	43.6

Damage Centroid Depth (x) (inches)	4.63	k^2	3290.26
Damage Centroid Depth (y) (inches)	25.99	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	386.40		

1995 CADILLAC ELDORADO - Side Impact

Curb Weight (pounds):	3773
Occupant + Cargo Weight (pounds):	218
Total Weight (pounds):	3991
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	2.0
Energy Crush Depth (inches):	9.56
Damage Length (inches):	156.0
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2904.73

		Equal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00	31.20	65.52	1.40	91.73	20.80	1362.82
C2 (inches)	4.20	31.20	347.88	6.30	2190.60	50.04	17408.35
C3 (inches)	18.10	31.20	577.20	9.25	5339.93	78.11	45086.50
C4 (inches)	18.90	31.20	397.80	6.87	2732.65	106.69	42441.98
C5 (inches)	6.60	31.20	102.96	2.20	226.51	135.20	13920.19
C6 (inches)	0.00						
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 9.56

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	bsub1
Minimum	39.9	19.4	17604.72	22631.80	13.0	12.3	17.1
Avg - 2 Std. Deviations	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Avg - 1 Std. Deviations	34.9	14.8	13784.93	17953.25	11.6	11.2	15.0
Average	51.2	31.9	27764.42	35005.49	16.2	15.1	21.9
Avg + 1 Std. Deviations	63.6	49.3	41743.91	51936.36	19.8	18.2	27.3
Avg + 2 Std. Deviations	74.2	67.0	55723.40	68804.44	22.7	20.9	31.8
Maximum	75.3	69.0	57327.90	70737.64	23.1	21.2	32.3

Damage Centroid Depth (x) (inches)	7.10	k^2	3374.76
Damage Centroid Depth (y) (inches)	80.61	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	1491.36		

2006 CHEVROLET IMPALA MSP POLICE PACKAGE - Front Impact

Curb Weight (pounds):	3725
Occupant + Cargo Weight (pounds):	39
Total Weight (pounds):	3764
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	5.0
Energy Crush Depth (inches):	7.36
Damage Length (inches):	52.5
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2670.92

"Known" Stiffness Values

	A	B
Average	323.9	99.7
Minimum	250.4	57.1
Maximum	494.8	229.5
Std. Devation	85.8	60.7

		Equal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00						
C2 (inches)	6.70	10.50	35.18	2.23	78.56	7.00	246.23
C3 (inches)	12.70	10.50	101.85	5.00	509.72	16.29	1659.26
C4 (inches)	10.60	10.50	122.33	5.84	714.47	26.09	3191.74
C5 (inches)	6.80	10.50	91.35	4.42	403.69	36.37	3322.20
C6 (inches)	0.00	10.50	35.70	2.27	80.92	45.50	1624.35
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 7.36

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)
Minimum	250.4	57.1	17604.72	18969.79	12.3	13.0	25.4
Avg - 2 Std. Deviations	152.3	-21.7	N/A	N/A	N/A	N/A	N/A
Avg - 1 Std. Deviations	238.1	39.0	13784.93	16655.57	11.5	11.9	23.1
Average	323.9	99.7	27764.42	27581.42	14.8	16.0	31.1
Avg + 1 Std. Deviations	409.7	160.4	41743.91	39372.58	17.7	19.3	37.6
Avg + 2 Std. Deviations	495.5	221.1	55723.40	51316.36	20.2	22.2	43.1
Maximum	494.8	229.5	57327.90	52449.46	20.4	22.5	43.6

Damage Centroid Depth (x) (inches)	4.63	k^2	3290.26
Damage Centroid Depth (y) (inches)	25.99	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	386.40		

1995 CADILLAC ELDORADO - Side Impact

Curb Weight (pounds):	3773
Occupant + Cargo Weight (pounds):	218
Total Weight (pounds):	3991
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	2.0
Energy Crush Depth (inches):	9.56
Damage Length (inches):	156.0
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2904.73

		Equal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00						
C2 (inches)	4.20	31.20	65.52	1.40	91.73	20.80	1362.82
C3 (inches)	18.10	31.20	347.88	6.30	2190.60	50.04	17408.35
C4 (inches)	18.90	31.20	577.20	9.25	5339.93	78.11	45086.50
C5 (inches)	6.60	31.20	397.80	6.87	2732.65	106.69	42441.98
C6 (inches)	0.00	31.20	102.96	2.20	226.51	135.20	13920.19
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 9.56

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	bsub1
Minimum	39.9	19.4	17604.72	22631.80	13.0	12.3	17.1
Avg - 2 Std. Deviations	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Avg - 1 Std. Deviations	34.9	14.8	13784.93	17953.25	11.6	11.2	15.0
Average	51.2	31.9	27764.42	35005.49	16.2	15.1	21.9
Avg + 1 Std. Deviations	63.6	49.3	41743.91	51936.36	19.8	18.2	27.3
Avg + 2 Std. Deviations	74.2	67.0	55723.40	68804.44	22.7	20.9	31.8
Maximum	75.3	69.0	57327.90	70737.64	23.1	21.2	32.3

Damage Centroid Depth (x) (inches)	7.10	k^2	3374.76
Damage Centroid Depth (y) (inches)	80.61	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	1491.36		

APPENDIX 3

Crush Length = OPTION 2

Impala Stiffness Values from NHTSA Tests = AVERAGE CRUSH

Crush Measurement Spacing = NON-EQUAL

Lever Arm and Angle = NO

Page 1 = “KNOWN” = Bullet
Page 2 = “UNKNOWN” = Target
Page 3 = The two pages combined onto 1

2006 CHEVROLET IMPALA MSP POLICE PACKAGE - Front Impact

Curb Weight (pounds):	3725
Occupant + Cargo Weight (pounds):	39
Total Weight (pounds):	3764
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	5.0
Energy Crush Depth (inches):	6.65
Damage Length (inches):	52.3
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2670.92

"Known" Stiffness Values

	A	B
Average	323.9	99.7
Minimum	250.4	57.1
Maximum	494.8	229.5
Std. Devation	85.8	60.7

		Unequal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00	17.70	84.96	3.20	271.87	11.80	1002.53
C2 (inches)	9.60	4.60	50.37	5.50	277.17	6.99	352.31
C3 (inches)	12.30	10.70	114.49	5.39	617.09	26.48	3032.08
C4 (inches)	9.10	12.20	82.35	3.51	289.16	41.99	3458.05
C5 (inches)	4.40	7.10	15.62	1.47	22.91	30.77	480.58
C6 (inches)	0.00						
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 6.65

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)
Minimum	250.4	57.1	16477.51	16683.88	11.5	12.6	24.5
Avg - 2 Std. Deviations	152.3	-21.7	209.07	N/A	N/A	1.0	2.0
Avg - 1 Std. Deviations	238.1	39.0	13008.32	14872.59	10.9	11.5	22.4
Average	323.9	99.7	25807.57	23961.89	13.8	15.4	29.9
Avg + 1 Std. Deviations	409.7	160.4	38606.81	33913.19	16.4	18.5	36.0
Avg + 2 Std. Deviations	495.5	221.1	51406.06	44016.54	18.7	21.2	41.3
Maximum	494.8	229.5	52848.50	44935.85	18.9	21.5	41.8

Damage Centroid Depth (x) (inches)	4.25	k^2	3290.26
Damage Centroid Depth (y) (inches)	23.94	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	347.79		

1995 CADILLAC ELDORADO - Side Impact

Curb Weight (pounds):	3773
Occupant + Cargo Weight (pounds):	218
Total Weight (pounds):	3991
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	2.0
Energy Crush Depth (inches):	9.61
Damage Length (inches):	155.9
Crush Profile Measurements:	10

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2904.73

		Unequal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00						
C2 (inches)	4.70	29.30	68.86	1.57	107.87	19.53	1344.97
C3 (inches)	9.60	18.30	130.85	3.71	486.08	28.50	3728.44
C4 (inches)	8.80	1.30	11.96	4.60	55.05	3.24	38.76
C5 (inches)	19.00	10.60	147.34	7.26	1069.96	37.75	5561.82
C6 (inches)	21.10	8.60	172.43	10.03	1730.19	38.78	6685.98
C7 (inches)	20.60	18.10	377.39	10.43	3934.43	99.51	37555.03
C8 (inches)	15.70	10.80	196.02	9.13	1789.69	69.96	13712.98
C9 (inches)	4.40	33.60	337.68	5.55	1875.61	248.85	84032.26
C10 (inches)	0.00	25.30	55.66	1.47	81.63	210.83	11734.98

Average Crush (inches): 9.61

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	bsub1
Minimum	38.5	18.0	16477.51	22025.79	12.9	11.9	16.5
Avg - 2 Std. Deviations	2.1	0.1	209.07	853.41	2.5	1.0	0.9
Avg - 1 Std. Deviations	33.7	13.9	13008.32	17596.68	11.5	10.9	14.5
Average	49.1	29.3	25807.57	33880.05	16.0	14.5	21.0
Avg + 1 Std. Deviations	60.9	45.2	38606.81	50063.60	19.4	17.5	26.1
Avg + 2 Std. Deviations	70.9	61.2	51406.06	66194.99	22.3	20.0	30.4
Maximum	72.0	63.1	52848.50	68010.62	22.6	20.3	30.8

Damage Centroid Depth (x) (inches)	7.43	k^2	3374.76
Damage Centroid Depth (y) (inches)	109.73	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	1498.18		

2006 CHEVROLET IMPALA MSP POLICE PACKAGE - Front Impact

Curb Weight (pounds):	3725
Occupant + Cargo Weight (pounds):	39
Total Weight (pounds):	3764
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	5.0
Energy Crush Depth (inches):	6.65
Damage Length (inches):	52.3
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2670.92

"Known" Stiffness Values

	A	B
Average	323.9	99.7
Minimum	250.4	57.1
Maximum	494.8	229.5
Std. Devation	85.8	60.7

	Unequal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches) 0.00						
C2 (inches) 9.60	17.70	84.96	3.20	271.87	11.80	1002.53
C3 (inches) 12.30	4.60	50.37	5.50	277.17	6.99	352.31
C4 (inches) 9.10	10.70	114.49	5.39	617.09	26.48	3032.08
C5 (inches) 4.40	12.20	82.35	3.51	289.16	41.99	3458.05
C6 (inches) 0.00	7.10	15.62	1.47	22.91	30.77	480.58
C7 (inches)						
C8 (inches)						
C9 (inches)						
C10 (inches)						

Average Crush (inches): 6.65

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)
Minimum	250.4	57.1	16477.51	16683.88	11.5	12.6	24.5
Avg - 2 Std. Deviations	152.3	-21.7	209.07	N/A	N/A	1.0	2.0
Avg - 1 Std. Deviations	238.1	39.0	13008.32	14872.59	10.9	11.5	22.4
Average	323.9	99.7	25807.57	23961.89	13.8	15.4	29.9
Avg + 1 Std. Deviations	409.7	160.4	38606.81	33913.19	16.4	18.5	36.0
Avg + 2 Std. Deviations	495.5	221.1	51406.06	44016.54	18.7	21.2	41.3
Maximum	494.8	229.5	52848.50	44935.85	18.9	21.5	41.8

Damage Centroid Depth (x) (inches)	4.25	k^2	3290.26
Damage Centroid Depth (y) (inches)	23.94	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	347.79		

1995 CADILLAC ELDORADO - Side Impact

Curb Weight (pounds):	3773
Occupant + Cargo Weight (pounds):	218
Total Weight (pounds):	3991
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	2.0
Energy Crush Depth (inches):	9.61
Damage Length (inches):	155.9
Crush Profile Measurements:	10

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2904.73

	Unequal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches) 0.00						
C2 (inches) 4.70	29.30	68.86	1.57	107.87	19.53	1344.97
C3 (inches) 9.60	18.30	130.85	3.71	486.08	28.50	3728.44
C4 (inches) 8.80	1.30	11.96	4.60	55.05	3.24	38.76
C5 (inches) 19.00	10.60	147.34	7.26	1069.96	37.75	5561.82
C6 (inches) 21.10	8.60	172.43	10.03	1730.19	38.78	6685.98
C7 (inches) 20.60	18.10	377.39	10.43	3934.43	99.51	37555.03
C8 (inches) 15.70	10.80	196.02	9.13	1789.69	69.96	13712.98
C9 (inches) 4.40	33.60	337.68	5.55	1875.61	248.85	84032.26
C10 (inches) 0.00	25.30	55.66	1.47	81.63	210.83	11734.98

Average Crush (inches): 9.61

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	bsub1
Minimum	38.5	18.0	16477.51	22025.79	12.9	11.9	16.5
Avg - 2 Std. Deviations	2.1	0.1	209.07	853.41	2.5	1.0	0.9
Avg - 1 Std. Deviations	33.7	13.9	13008.32	17596.68	11.5	10.9	14.5
Average	49.1	29.3	25807.57	33880.05	16.0	14.5	21.0
Avg + 1 Std. Deviations	60.9	45.2	38606.81	50063.60	19.4	17.5	26.1
Avg + 2 Std. Deviations	70.9	61.2	51406.06	66194.99	22.3	20.0	30.4
Maximum	72.0	63.1	52848.50	68010.62	22.6	20.3	30.8

Damage Centroid Depth (x) (inches)	7.43	k^2	3374.76
Damage Centroid Depth (y) (inches)	109.73	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	1498.18		

APPENDIX 3

Crush Length = OPTION 1

Impala Stiffness Values from NHTSA Tests = AVERAGE CRUSH

Crush Measurement Spacing = EQUAL

Lever Arm and Angle = YES

Page 1 = "KNOWN" = Bullet
Page 2 = "UNKNOWN" = Target
Page 3 = The two pages combined onto 1

2006 CHEVROLET IMPALA MSP POLICE PACKAGE - Front Impact

Curb Weight (pounds):	3725
Occupant + Cargo Weight (pounds):	39
Total Weight (pounds):	3764
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	5.0
Energy Crush Depth (inches):	7.36
Damage Length (inches):	52.5
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2670.92

"Known" Stiffness Values

	A	B
Average	323.9	99.7
Minimum	250.4	57.1
Maximum	494.8	229.5
Std. Devation	85.8	60.7

		Equal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00	10.50	35.18	2.23	78.56	7.00	246.23
C2 (inches)	6.70	10.50	101.85	5.00	509.72	16.29	1659.26
C3 (inches)	12.70	10.50	122.33	5.84	714.47	26.09	3191.74
C4 (inches)	10.60	10.50	91.35	4.42	403.69	36.37	3322.20
C5 (inches)	6.80	10.50	35.70	2.27	80.92	45.50	1624.35
C6 (inches)	0.00						
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 7.36

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)
Minimum	250.4	57.1	17604.72	18969.79	12.3	12.4	27.0
Avg - 2 Std. Deviations	152.3	-21.7	N/A	N/A	N/A	N/A	N/A
Avg - 1 Std. Deviations	238.1	39.0	13784.93	16655.57	11.5	11.4	24.7
Average	323.9	99.7	27764.42	27581.42	14.8	15.2	33.1
Avg + 1 Std. Deviations	409.7	160.4	41743.91	39372.58	17.7	18.4	39.9
Avg + 2 Std. Deviations	495.5	221.1	55723.40	51316.36	20.2	21.1	45.8
Maximum	494.8	229.5	57327.90	52449.46	20.4	21.3	46.3

Damage Centroid Depth (x) (inches)	4.63	k^2	3290.26
Damage Centroid Depth (y) (inches)	25.99	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	386.40		

1995 CADILLAC ELDORADO - Side Impact

Curb Weight (pounds):	3773
Occupant + Cargo Weight (pounds):	218
Total Weight (pounds):	3991
Angle Coll Force to Normal (degrees):	30.0
No Damage Speed (mph):	2.0
Energy Crush Depth (inches):	8.84
Damage Length (inches):	100.0
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	28.50
Yaw Moment of Inertia (lb-ft-sec^2)	2904.73

		Equal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00	20.00	50.00	1.67	83.33	13.33	666.67
C2 (inches)	5.00	20.00	207.00	5.64	1166.63	31.72	6566.67
C3 (inches)	15.70	20.00	320.00	8.00	2560.30	50.06	16020.00
C4 (inches)	16.30	20.00	235.00	6.17	1449.63	68.71	16146.67
C5 (inches)	7.20	20.00	72.00	2.40	172.80	86.67	6240.00
C6 (inches)	0.00						
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 8.84

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	bsub1
Minimum	59.6	27.7	17604.72	23318.14	13.2	11.7	16.4
Avg - 2 Std. Deviations	N/A	0.0	N/A	510.68	2.0	N/A	N/A
Avg - 1 Std. Deviations	52.0	21.1	13784.93	18572.82	11.8	10.7	14.3
Average	76.5	45.7	27764.42	35840.94	16.4	14.4	21.0
Avg + 1 Std. Deviations	95.4	71.0	41743.91	52938.28	19.9	17.3	26.2
Avg + 2 Std. Deviations	111.2	96.6	55723.40	69947.21	22.9	19.9	30.6
Maximum	112.9	99.5	57327.90	71895.40	23.2	20.1	31.0

Damage Centroid Depth (x) (inches)	6.15	k^2	3374.76
Damage Centroid Depth (y) (inches)	51.63	Eff. Mass Ratio (gamma)	0.81
Area of Damage (inches^2):	884.00		

2006 CHEVROLET IMPALA MSP POLICE PACKAGE - Front Impact

Curb Weight (pounds):	3725
Occupant + Cargo Weight (pounds):	39
Total Weight (pounds):	3764
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	5.0
Energy Crush Depth (inches):	7.36
Damage Length (inches):	52.5
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2670.92

"Known" Stiffness Values

	A	B
Average	323.9	99.7
Minimum	250.4	57.1
Maximum	494.8	229.5
Std. Devation	85.8	60.7

		Equal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00						
C2 (inches)	6.70	10.50	35.18	2.23	78.56	7.00	246.23
C3 (inches)	12.70	10.50	101.85	5.00	509.72	16.29	1659.26
C4 (inches)	10.60	10.50	122.33	5.84	714.47	26.09	3191.74
C5 (inches)	6.80	10.50	91.35	4.42	403.69	36.37	3322.20
C6 (inches)	0.00	10.50	35.70	2.27	80.92	45.50	1624.35
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 7.36

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)
Minimum	250.4	57.1	17604.72	18969.79	12.3	12.4	27.0
Avg - 2 Std. Deviations	152.3	-21.7	N/A	N/A	N/A	N/A	N/A
Avg - 1 Std. Deviations	238.1	39.0	13784.93	16655.57	11.5	11.4	24.7
Average	323.9	99.7	27764.42	27581.42	14.8	15.2	33.1
Avg + 1 Std. Deviations	409.7	160.4	41743.91	39372.58	17.7	18.4	39.9
Avg + 2 Std. Deviations	495.5	221.1	55723.40	51316.36	20.2	21.1	45.8
Maximum	494.8	229.5	57327.90	52449.46	20.4	21.3	46.3

Damage Centroid Depth (x) (inches)	4.63	k^2	3290.26
Damage Centroid Depth (y) (inches)	25.99	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	386.40		

1995 CADILLAC ELDORADO - Side Impact

Curb Weight (pounds):	3773
Occupant + Cargo Weight (pounds):	218
Total Weight (pounds):	3991
Angle Coll Force to Normal (degrees):	30.0
No Damage Speed (mph):	2.0
Energy Crush Depth (inches):	8.84
Damage Length (inches):	100.0
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	28.50
Yaw Moment of Inertia (lb-ft-sec^2)	2904.73

		Equal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00						
C2 (inches)	5.00	20.00	50.00	1.67	83.33	13.33	666.67
C3 (inches)	15.70	20.00	207.00	5.64	1166.63	31.72	6566.67
C4 (inches)	16.30	20.00	320.00	8.00	2560.30	50.06	16020.00
C5 (inches)	7.20	20.00	235.00	6.17	1449.63	68.71	16146.67
C6 (inches)	0.00	20.00	72.00	2.40	172.80	86.67	6240.00
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 8.84

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	bsub1
Minimum	59.6	27.7	17604.72	23318.14	13.2	11.7	16.4
Avg - 2 Std. Deviations	N/A	0.0	N/A	510.68	2.0	N/A	N/A
Avg - 1 Std. Deviations	52.0	21.1	13784.93	18572.82	11.8	10.7	14.3
Average	76.5	45.7	27764.42	35840.94	16.4	14.4	21.0
Avg + 1 Std. Deviations	95.4	71.0	41743.91	52938.28	19.9	17.3	26.2
Avg + 2 Std. Deviations	111.2	96.6	55723.40	69947.21	22.9	19.9	30.6
Maximum	112.9	99.5	57327.90	71895.40	23.2	20.1	31.0

Damage Centroid Depth (x) (inches)	6.15	k^2	3374.76
Damage Centroid Depth (y) (inches)	51.63	Eff. Mass Ratio (gamma)	0.81
Area of Damage (inches^2):	884.00		

APPENDIX 3

Crush Length = OPTION 1

Impala Stiffness Values from NHTSA Tests = AVERAGE CRUSH

Crush Measurement Spacing = NON-EQUAL

Lever Arm and Angle = YES

Page 1 = “KNOWN” = Bullet
Page 2 = “UNKNOWN” = Target
Page 3 = The two pages combined onto 1

2006 CHEVROLET IMPALA MSP POLICE PACKAGE - Front Impact

Curb Weight (pounds):	3725
Occupant + Cargo Weight (pounds):	39
Total Weight (pounds):	3764
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	5.0
Energy Crush Depth (inches):	12.76
Damage Length (inches):	52.3
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2670.92

"Known" Stiffness Values

	A	B
Average	323.9	99.7
Minimum	250.4	57.1
Maximum	494.8	229.5
Std. Devation	85.8	60.7

		Unequal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00						
C2 (inches)	9.60	17.70	84.96	3.20	271.87	11.80	1002.53
C3 (inches)	12.30	4.60	50.37	5.50	277.17	6.99	352.31
C4 (inches)	9.10	10.70	114.49	5.39	617.09	26.48	3032.08
C5 (inches)	4.40	12.20	82.35	3.51	289.16	41.99	3458.05
C6 (inches)	0.00	7.10	15.62	1.47	22.91	30.77	480.58
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 6.65

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)
Minimum	250.4	57.1	25607.60	16683.88	11.5	12.2	26.5
Avg - 2 Std. Deviations	152.3	-21.7	N/A	N/A	N/A	N/A	N/A
Avg - 1 Std. Deviations	238.1	39.0	19244.29	14872.59	10.9	11.1	24.1
Average	323.9	99.7	41749.26	23961.89	13.8	15.0	32.5
Avg + 1 Std. Deviations	409.7	160.4	64254.23	33913.19	16.4	18.1	39.3
Avg + 2 Std. Deviations	495.5	221.1	86759.20	44016.54	18.7	20.7	45.0
Maximum	494.8	229.5	89544.77	44935.85	18.9	21.0	45.6

Damage Centroid Depth (x) (inches)	4.25	k^2	3290.26
Damage Centroid Depth (y) (inches)	23.94	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	347.79		

1995 CADILLAC ELDORADO - Side Impact

Curb Weight (pounds):	3773
Occupant + Cargo Weight (pounds):	218
Total Weight (pounds):	3991
Angle Coll Force to Normal (degrees):	30.0
No Damage Speed (mph):	2.0
Energy Crush Depth (inches):	30.56
Damage Length (inches):	100.4
Crush Profile Measurements:	8

PDOF

Lever Arm Distance (inches):	28.50
Yaw Moment of Inertia (lb-ft-sec^2)	2904.73

		Unequal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00	19.80	108.90	3.67	399.30	13.20	1437.48
C2 (inches)	11.00	1.30	13.85	5.33	73.75	1.94	26.90
C3 (inches)	10.30	10.90	188.57	9.12	1720.15	27.99	5277.14
C4 (inches)	24.30	17.20	413.66	12.03	4974.44	60.17	24890.01
C5 (inches)	23.80	9.60	210.72	11.00	2318.13	43.07	9074.69
C6 (inches)	20.10	10.60	176.49	8.44	1490.31	57.93	10224.76
C7 (inches)	13.20	31.00	204.60	4.40	900.24	196.33	40169.80
C8 (inches)	0.00						
C9 (inches)							
C10 (inches)							

Average Crush (inches): 13.12

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	bsub1
Minimum	40.9	13.1	25607.60	24007.84	13.4	11.5	11.3
Avg - 2 Std. Deviations	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Avg - 1 Std. Deviations	35.2	9.7	19244.29	18678.59	11.8	10.5	9.7
Average	52.8	21.8	41749.26	37258.03	16.7	14.1	14.6
Avg + 1 Std. Deviations	66.0	34.1	64254.23	55383.45	20.4	17.1	18.2
Avg + 2 Std. Deviations	77.0	46.5	86759.20	73285.21	23.5	19.6	21.2
Maximum	78.3	48.0	89544.77	75490.18	23.8	19.8	21.6

Damage Centroid Depth (x) (inches)	9.02	k^2	3374.76
Damage Centroid Depth (y) (inches)	69.18	Eff. Mass Ratio (gamma)	0.81
Area of Damage (inches^2):	1316.79		

2006 CHEVROLET IMPALA MSP POLICE PACKAGE - Front Impact

Curb Weight (pounds):	3725
Occupant + Cargo Weight (pounds):	39
Total Weight (pounds):	3764
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	5.0
Energy Crush Depth (inches):	12.76
Damage Length (inches):	52.3
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2670.92

"Known" Stiffness Values

	A	B
Average	323.9	99.7
Minimum	250.4	57.1
Maximum	494.8	229.5
Std. Devation	85.8	60.7

		Unequal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00						
C2 (inches)	9.60	17.70	84.96	3.20	271.87	11.80	1002.53
C3 (inches)	12.30	4.60	50.37	5.50	277.17	6.99	352.31
C4 (inches)	9.10	10.70	114.49	5.39	617.09	26.48	3032.08
C5 (inches)	4.40	12.20	82.35	3.51	289.16	41.99	3458.05
C6 (inches)	0.00	7.10	15.62	1.47	22.91	30.77	480.58
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 6.65

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)
Minimum	250.4	57.1	25607.60	16683.88	11.5	12.2	26.5
Avg - 2 Std. Deviations	152.3	-21.7	N/A	N/A	N/A	N/A	N/A
Avg - 1 Std. Deviations	238.1	39.0	19244.29	14872.59	10.9	11.1	24.1
Average	323.9	99.7	41749.26	23961.89	13.8	15.0	32.5
Avg + 1 Std. Deviations	409.7	160.4	64254.23	33913.19	16.4	18.1	39.3
Avg + 2 Std. Deviations	495.5	221.1	86759.20	44016.54	18.7	20.7	45.0
Maximum	494.8	229.5	89544.77	44935.85	18.9	21.0	45.6

Damage Centroid Depth (x) (inches)	4.25	k^2	3290.26
Damage Centroid Depth (y) (inches)	23.94	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	347.79		

1995 CADILLAC ELDORADO - Side Impact

Curb Weight (pounds):	3773
Occupant + Cargo Weight (pounds):	218
Total Weight (pounds):	3991
Angle Coll Force to Normal (degrees):	30.0
No Damage Speed (mph):	2.0
Energy Crush Depth (inches):	30.56
Damage Length (inches):	100.4
Crush Profile Measurements:	8

PDOF

Lever Arm Distance (inches):	28.50
Yaw Moment of Inertia (lb-ft-sec^2)	2904.73

		Unequal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00						
C2 (inches)	11.00	19.80	108.90	3.67	399.30	13.20	1437.48
C3 (inches)	10.30	1.30	13.85	5.33	73.75	1.94	26.90
C4 (inches)	24.30	10.90	188.57	9.12	1720.15	27.99	5277.14
C5 (inches)	23.80	17.20	413.66	12.03	4974.44	60.17	24890.01
C6 (inches)	20.10	9.60	210.72	11.00	2318.13	43.07	9074.69
C7 (inches)	13.20	10.60	176.49	8.44	1490.31	57.93	10224.76
C8 (inches)	0.00	31.00	204.60	4.40	900.24	196.33	40169.80
C9 (inches)							
C10 (inches)							

Average Crush (inches): 13.12

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	bsub1
Minimum	40.9	13.1	25607.60	24007.84	13.4	11.5	11.3
Avg - 2 Std. Deviations	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Avg - 1 Std. Deviations	35.2	9.7	19244.29	18678.59	11.8	10.5	9.7
Average	52.8	21.8	41749.26	37258.03	16.7	14.1	14.6
Avg + 1 Std. Deviations	66.0	34.1	64254.23	55383.45	20.4	17.1	18.2
Avg + 2 Std. Deviations	77.0	46.5	86759.20	73285.21	23.5	19.6	21.2
Maximum	78.3	48.0	89544.77	75490.18	23.8	19.8	21.6

Damage Centroid Depth (x) (inches)	9.02	k^2	3374.76
Damage Centroid Depth (y) (inches)	69.18	Eff. Mass Ratio (gamma)	0.81
Area of Damage (inches^2):	1316.79		

APPENDIX 3

Crush Length = OPTION 2

Impala Stiffness Values from NHTSA Tests = AVERAGE CRUSH

Crush Measurement Spacing = EQUAL

Lever Arm and Angle = YES

Page 1 = "KNOWN" = Bullet
Page 2 = "UNKNOWN" = Target
Page 3 = The two pages combined onto 1

2006 CHEVROLET IMPALA MSP POLICE PACKAGE - Front Impact

Curb Weight (pounds):	3725
Occupant + Cargo Weight (pounds):	39
Total Weight (pounds):	3764
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	5.0
Energy Crush Depth (inches):	7.36
Damage Length (inches):	52.5
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2670.92

"Known" Stiffness Values

	A	B
Average	323.9	99.7
Minimum	250.4	57.1
Maximum	494.8	229.5
Std. Devation	85.8	60.7

		Equal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00	10.50	35.18	2.23	78.56	7.00	246.23
C2 (inches)	6.70	10.50	101.85	5.00	509.72	16.29	1659.26
C3 (inches)	12.70	10.50	122.33	5.84	714.47	26.09	3191.74
C4 (inches)	10.60	10.50	91.35	4.42	403.69	36.37	3322.20
C5 (inches)	6.80	10.50	35.70	2.27	80.92	45.50	1624.35
C6 (inches)	0.00						
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 7.36

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)
Minimum	250.4	57.1	17604.72	18969.79	12.3	12.9	28.0
Avg - 2 Std. Deviations	152.3	-21.7	N/A	N/A	N/A	N/A	N/A
Avg - 1 Std. Deviations	238.1	39.0	13784.93	16655.57	11.5	11.7	25.5
Average	323.9	99.7	27764.42	27581.42	14.8	15.8	34.3
Avg + 1 Std. Deviations	409.7	160.4	41743.91	39372.58	17.7	19.1	41.5
Avg + 2 Std. Deviations	495.5	221.1	55723.40	51316.36	20.2	21.9	47.6
Maximum	494.8	229.5	57327.90	52449.46	20.4	22.2	48.2

Damage Centroid Depth (x) (inches)	4.63	k^2	3290.26
Damage Centroid Depth (y) (inches)	25.99	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	386.40		

1995 CADILLAC ELDORADO - Side Impact

Curb Weight (pounds):	3773
Occupant + Cargo Weight (pounds):	218
Total Weight (pounds):	3991
Angle Coll Force to Normal (degrees):	30.0
No Damage Speed (mph):	2.0
Energy Crush Depth (inches):	9.56
Damage Length (inches):	156.0
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	28.50
Yaw Moment of Inertia (lb-ft-sec^2)	2904.73

		Equal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00	31.20	65.52	1.40	91.73	20.80	1362.82
C2 (inches)	4.20	31.20	347.88	6.30	2190.60	50.04	17408.35
C3 (inches)	18.10	31.20	577.20	9.25	5339.93	78.11	45086.50
C4 (inches)	18.90	31.20	397.80	6.87	2732.65	106.69	42441.98
C5 (inches)	6.60	31.20	102.96	2.20	226.51	135.20	13920.19
C6 (inches)	0.00						
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 9.56

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	bsub1
Minimum	36.9	16.6	17604.72	26327.06	14.1	12.2	15.8
Avg - 2 Std. Deviations	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Avg - 1 Std. Deviations	32.2	12.6	13784.93	20910.99	12.5	11.1	13.8
Average	47.3	27.3	27764.42	40645.67	17.5	14.9	20.3
Avg + 1 Std. Deviations	58.9	42.3	41743.91	60229.99	21.3	18.0	25.3
Avg + 2 Std. Deviations	68.7	57.5	55723.40	79736.48	24.5	20.7	29.5
Maximum	69.8	59.3	57327.90	81971.82	24.8	20.9	29.9

Damage Centroid Depth (x) (inches)	7.10	k^2	3374.76
Damage Centroid Depth (y) (inches)	80.61	Eff. Mass Ratio (gamma)	0.81
Area of Damage (inches^2):	1491.36		

2006 CHEVROLET IMPALA MSP POLICE PACKAGE - Front Impact

Curb Weight (pounds):	3725
Occupant + Cargo Weight (pounds):	39
Total Weight (pounds):	3764
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	5.0
Energy Crush Depth (inches):	7.36
Damage Length (inches):	52.5
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2670.92

"Known" Stiffness Values

	A	B
Average	323.9	99.7
Minimum	250.4	57.1
Maximum	494.8	229.5
Std. Devation	85.8	60.7

		Equal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00						
C2 (inches)	6.70	10.50	35.18	2.23	78.56	7.00	246.23
C3 (inches)	12.70	10.50	101.85	5.00	509.72	16.29	1659.26
C4 (inches)	10.60	10.50	122.33	5.84	714.47	26.09	3191.74
C5 (inches)	6.80	10.50	91.35	4.42	403.69	36.37	3322.20
C6 (inches)	0.00	10.50	35.70	2.27	80.92	45.50	1624.35
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 7.36

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)
Minimum	250.4	57.1	17604.72	18969.79	12.3	12.9	28.0
Avg - 2 Std. Deviations	152.3	-21.7	N/A	N/A	N/A	N/A	N/A
Avg - 1 Std. Deviations	238.1	39.0	13784.93	16655.57	11.5	11.7	25.5
Average	323.9	99.7	27764.42	27581.42	14.8	15.8	34.3
Avg + 1 Std. Deviations	409.7	160.4	41743.91	39372.58	17.7	19.1	41.5
Avg + 2 Std. Deviations	495.5	221.1	55723.40	51316.36	20.2	21.9	47.6
Maximum	494.8	229.5	57327.90	52449.46	20.4	22.2	48.2

Damage Centroid Depth (x) (inches)	4.63	k^2	3290.26
Damage Centroid Depth (y) (inches)	25.99	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	386.40		

1995 CADILLAC ELDORADO - Side Impact

Curb Weight (pounds):	3773
Occupant + Cargo Weight (pounds):	218
Total Weight (pounds):	3991
Angle Coll Force to Normal (degrees):	30.0
No Damage Speed (mph):	2.0
Energy Crush Depth (inches):	9.56
Damage Length (inches):	156.0
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	28.50
Yaw Moment of Inertia (lb-ft-sec^2)	2904.73

		Equal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00						
C2 (inches)	4.20	31.20	65.52	1.40	91.73	20.80	1362.82
C3 (inches)	18.10	31.20	347.88	6.30	2190.60	50.04	17408.35
C4 (inches)	18.90	31.20	577.20	9.25	5339.93	78.11	45086.50
C5 (inches)	6.60	31.20	397.80	6.87	2732.65	106.69	42441.98
C6 (inches)	0.00	31.20	102.96	2.20	226.51	135.20	13920.19
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 9.56

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	bsub1
Minimum	36.9	16.6	17604.72	26327.06	14.1	12.2	15.8
Avg - 2 Std. Deviations	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Avg - 1 Std. Deviations	32.2	12.6	13784.93	20910.99	12.5	11.1	13.8
Average	47.3	27.3	27764.42	40645.67	17.5	14.9	20.3
Avg + 1 Std. Deviations	58.9	42.3	41743.91	60229.99	21.3	18.0	25.3
Avg + 2 Std. Deviations	68.7	57.5	55723.40	79736.48	24.5	20.7	29.5
Maximum	69.8	59.3	57327.90	81971.82	24.8	20.9	29.9

Damage Centroid Depth (x) (inches)	7.10	k^2	3374.76
Damage Centroid Depth (y) (inches)	80.61	Eff. Mass Ratio (gamma)	0.81
Area of Damage (inches^2):	1491.36		

APPENDIX 3

Crush Length = OPTION 2

Impala Stiffness Values from NHTSA Tests = AVERAGE CRUSH

Crush Measurement Spacing = NON-EQUAL

Lever Arm and Angle = YES

Page 1 = “KNOWN” = Bullet
Page 2 = “UNKNOWN” = Target
Page 3 = The two pages combined onto 1

2006 CHEVROLET IMPALA MSP POLICE PACKAGE - Front Impact

Curb Weight (pounds):	3725
Occupant + Cargo Weight (pounds):	39
Total Weight (pounds):	3764
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	5.0
Energy Crush Depth (inches):	12.76
Damage Length (inches):	52.3
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2670.92

"Known" Stiffness Values

	A	B
Average	323.9	99.7
Minimum	250.4	57.1
Maximum	494.8	229.5
Std. Devation	85.8	60.7

		Unequal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00						
C2 (inches)	9.60	17.70	84.96	3.20	271.87	11.80	1002.53
C3 (inches)	12.30	4.60	50.37	5.50	277.17	6.99	352.31
C4 (inches)	9.10	10.70	114.49	5.39	617.09	26.48	3032.08
C5 (inches)	4.40	12.20	82.35	3.51	289.16	41.99	3458.05
C6 (inches)	0.00	7.10	15.62	1.47	22.91	30.77	480.58
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 6.65

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)
Minimum	250.4	57.1	25607.60	16683.88	11.5	11.5	24.9
Avg - 2 Std. Deviations	152.3	-21.7	N/A	N/A	N/A	N/A	N/A
Avg - 1 Std. Deviations	238.1	39.0	19244.29	14872.59	10.9	10.5	22.7
Average	323.9	99.7	41749.26	23961.89	13.8	14.0	30.4
Avg + 1 Std. Deviations	409.7	160.4	64254.23	33913.19	16.4	16.9	36.7
Avg + 2 Std. Deviations	495.5	221.1	86759.20	44016.54	18.7	19.4	42.0
Maximum	494.8	229.5	89544.77	44935.85	18.9	19.6	42.6

Damage Centroid Depth (x) (inches)	4.25	k^2	3290.26
Damage Centroid Depth (y) (inches)	23.94	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	347.79		

1995 CADILLAC ELDORADO - Side Impact

Curb Weight (pounds):	3773
Occupant + Cargo Weight (pounds):	218
Total Weight (pounds):	3991
Angle Coll Force to Normal (degrees):	30.0
No Damage Speed (mph):	2.0
Energy Crush Depth (inches):	23.29
Damage Length (inches):	155.9
Crush Profile Measurements:	10

PDOF

Lever Arm Distance (inches):	28.50
Yaw Moment of Inertia (lb-ft-sec^2)	2904.73

		Unequal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00						
C2 (inches)	4.70	29.30	68.86	1.57	107.87	19.53	1344.97
C3 (inches)	9.60	18.30	130.85	3.71	486.08	28.50	3728.44
C4 (inches)	8.80	1.30	11.96	4.60	55.05	3.24	38.76
C5 (inches)	19.00	10.60	147.34	7.26	1069.96	37.75	5561.82
C6 (inches)	21.10	8.60	172.43	10.03	1730.19	38.78	6685.98
C7 (inches)	20.60	18.10	377.39	10.43	3934.43	99.51	37555.03
C8 (inches)	15.70	10.80	196.02	9.13	1789.69	69.96	13712.98
C9 (inches)	4.40	33.60	337.68	5.55	1875.61	248.85	84032.26
C10 (inches)	0.00	25.30	55.66	1.47	81.63	210.83	11734.98

Average Crush (inches): 9.61

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	bsub1
Minimum	30.0	10.9	25607.60	19218.06	12.0	10.8	12.8
Avg - 2 Std. Deviations	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Avg - 1 Std. Deviations	25.8	8.1	19244.29	14986.33	10.6	9.9	11.0
Average	38.7	18.3	41749.26	29735.18	15.0	13.2	16.6
Avg + 1 Std. Deviations	48.5	28.6	64254.23	44116.15	18.2	15.9	20.8
Avg + 2 Std. Deviations	56.6	39.0	86759.20	58315.84	20.9	18.3	24.2
Maximum	57.5	40.3	89544.77	60064.63	21.2	18.5	24.6

Damage Centroid Depth (x) (inches)	7.43	k^2	3374.76
Damage Centroid Depth (y) (inches)	109.73	Eff. Mass Ratio (gamma)	0.81
Area of Damage (inches^2):	1498.18		

2006 CHEVROLET IMPALA MSP POLICE PACKAGE - Front Impact

Curb Weight (pounds):	3725
Occupant + Cargo Weight (pounds):	39
Total Weight (pounds):	3764
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	5.0
Energy Crush Depth (inches):	12.76
Damage Length (inches):	52.3
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2670.92

"Known" Stiffness Values

	A	B
Average	323.9	99.7
Minimum	250.4	57.1
Maximum	494.8	229.5
Std. Devation	85.8	60.7

	Unequal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches) 0.00						
C2 (inches) 9.60	17.70	84.96	3.20	271.87	11.80	1002.53
C3 (inches) 12.30	4.60	50.37	5.50	277.17	6.99	352.31
C4 (inches) 9.10	10.70	114.49	5.39	617.09	26.48	3032.08
C5 (inches) 4.40	12.20	82.35	3.51	289.16	41.99	3458.05
C6 (inches) 0.00	7.10	15.62	1.47	22.91	30.77	480.58
C7 (inches)						
C8 (inches)						
C9 (inches)						
C10 (inches)						

Average Crush (inches): 6.65

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)
Minimum	250.4	57.1	25607.60	16683.88	11.5	11.5	24.9
Avg - 2 Std. Deviations	152.3	-21.7	N/A	N/A	N/A	N/A	N/A
Avg - 1 Std. Deviations	238.1	39.0	19244.29	14872.59	10.9	10.5	22.7
Average	323.9	99.7	41749.26	23961.89	13.8	14.0	30.4
Avg + 1 Std. Deviations	409.7	160.4	64254.23	33913.19	16.4	16.9	36.7
Avg + 2 Std. Deviations	495.5	221.1	86759.20	44016.54	18.7	19.4	42.0
Maximum	494.8	229.5	89544.77	44935.85	18.9	19.6	42.6

Damage Centroid Depth (x) (inches)	4.25	k^2	3290.26
Damage Centroid Depth (y) (inches)	23.94	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	347.79		

1995 CADILLAC ELDORADO - Side Impact

Curb Weight (pounds):	3773
Occupant + Cargo Weight (pounds):	218
Total Weight (pounds):	3991
Angle Coll Force to Normal (degrees):	30.0
No Damage Speed (mph):	2.0
Energy Crush Depth (inches):	23.29
Damage Length (inches):	155.9
Crush Profile Measurements:	10

PDOF

Lever Arm Distance (inches):	28.50
Yaw Moment of Inertia (lb-ft-sec^2)	2904.73

	Unequal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches) 0.00						
C2 (inches) 4.70	29.30	68.86	1.57	107.87	19.53	1344.97
C3 (inches) 9.60	18.30	130.85	3.71	486.08	28.50	3728.44
C4 (inches) 8.80	1.30	11.96	4.60	55.05	3.24	38.76
C5 (inches) 19.00	10.60	147.34	7.26	1069.96	37.75	5561.82
C6 (inches) 21.10	8.60	172.43	10.03	1730.19	38.78	6685.98
C7 (inches) 20.60	18.10	377.39	10.43	3934.43	99.51	37555.03
C8 (inches) 15.70	10.80	196.02	9.13	1789.69	69.96	13712.98
C9 (inches) 4.40	33.60	337.68	5.55	1875.61	248.85	84032.26
C10 (inches) 0.00	25.30	55.66	1.47	81.63	210.83	11734.98

Average Crush (inches): 9.61

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	bsub1
Minimum	30.0	10.9	25607.60	19218.06	12.0	10.8	12.8
Avg - 2 Std. Deviations	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Avg - 1 Std. Deviations	25.8	8.1	19244.29	14986.33	10.6	9.9	11.0
Average	38.7	18.3	41749.26	29735.18	15.0	13.2	16.6
Avg + 1 Std. Deviations	48.5	28.6	64254.23	44116.15	18.2	15.9	20.8
Avg + 2 Std. Deviations	56.6	39.0	86759.20	58315.84	20.9	18.3	24.2
Maximum	57.5	40.3	89544.77	60064.63	21.2	18.5	24.6

Damage Centroid Depth (x) (inches)	7.43	k^2	3374.76
Damage Centroid Depth (y) (inches)	109.73	Eff. Mass Ratio (gamma)	0.81
Area of Damage (inches^2):	1498.18		

APPENDIX 3

NHTSA Tests for
MAXIMUM CRUSH
Stiffness Value Determination

Available Test Results
Front Impact Test Summary

Report Filter Settings

Year Range: 2006 - 2013
Make: CHEVROLET
Model: IMPALA

Test Number	Vehicle Info	No Damage Speed (mph)	Max Crush (inch)	Closing Speed (mph)	Vehicle Stiffness A	Vehicle Stiffness B	Vehicle Width Values G	Vehicle Width Values Kv	Crush Factor
7496	2012 CHEVROLET IMPALA FOUR DOOR SEDAN	5.0	15.4	20.0	207.6	40.4	533.3	71.8	10.4
5578	2006 CHEVROLET MONTE CARLO TWO DOOR C...	5.0	28.0	35.0	235.7	50.6	549.0	68.9	17.5
5547	2006 CHEVROLET IMPALA FOUR DOOR SEDAN	5.0	28.3	35.2	240.8	51.2	565.9	69.6	17.4
5468	2006 PONTIAC GRAND PRIX FOUR DOOR SEDAN	5.0	26.7	35.1	249.3	56.1	553.6	76.3	18.4
7488	2012 CHEVROLET IMPALA FOUR DOOR SEDAN	5.0	26.5	34.9	253.9	57.2	563.5	77.9	18.4
5274	2005 BUICK LACROSSE FOUR DOOR SEDAN	5.0	24.9	35.1	269.7	65.2	558.3	88.6	19.8
6052	2007 CHEVROLET IMPALA FOUR DOOR SEDAN	5.0	13.9	24.7	340.6	96.4	601.5	151.5	17.6
	Average (AVG)				**256.8**	**59.6**	**560.7**	**86.4**	**17.1**
	Minimum (MIN)				**207.6**	**40.4**	**533.3**	**68.9**	**10.4**
	Maximum (MAX)				**340.6**	**96.4**	**601.5**	**151.5**	**19.8**
	Standard Deviation (STDev-sample)				**41.6**	**17.9**	**21.0**	**29.5**	**3.1**
	Number of Tests (n)			**7**					

APPENDIX 3

Crush Length = OPTION 1

Impala Stiffness Values from NHTSA Tests = MAXIMUM CRUSH

Crush Measurement Spacing = EQUAL

Lever Arm and Angle = NO

Page 1 = "KNOWN" = Bullet
Page 2 = "UNKNOWN" = Target
Page 3 = The two pages combined onto 1

2006 CHEVROLET IMPALA MSP POLICE PACKAGE - Front Impact

Curb Weight (pounds):	3725
Occupant + Cargo Weight (pounds):	39
Total Weight (pounds):	3764
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	5.0
Energy Crush Depth (inches):	7.36
Damage Length (inches):	52.5
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2670.92

"Known" Stiffness Values

	A	B
Average	256.8	59.6
Minimum	207.6	40.4
Maximum	340.6	96.4
Std. Devation	41.6	17.9

		Equal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00	10.50	35.18	2.23	78.56	7.00	246.23
C2 (inches)	6.70	10.50	101.85	5.00	509.72	16.29	1659.26
C3 (inches)	12.70	10.50	122.33	5.84	714.47	26.09	3191.74
C4 (inches)	10.60	10.50	91.35	4.42	403.69	36.37	3322.20
C5 (inches)	6.80	10.50	35.70	2.27	80.92	45.50	1624.35
C6 (inches)	0.00						
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 7.36

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)
Minimum	207.6	40.4	13254.78	15035.75	10.9	11.2	21.7
Avg - 2 Std. Deviations	173.6	23.8	9155.16	11904.80	9.7	9.7	18.8
Avg - 1 Std. Deviations	215.2	41.7	13705.44	15569.91	11.1	11.3	22.0
Average	256.8	59.6	18255.72	19566.62	12.5	12.8	24.9
Avg + 1 Std. Deviations	298.4	77.5	22806.00	23665.16	13.7	14.2	27.6
Avg + 2 Std. Deviations	340.0	95.4	27356.28	27808.21	14.9	15.4	30.0
Maximum	340.6	96.4	27565.23	27958.25	14.9	15.5	30.1

Damage Centroid Depth (x) (inches)	4.63	k^2	3290.26
Damage Centroid Depth (y) (inches)	25.99	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	386.40		

1995 CADILLAC ELDORADO - Side Impact

Curb Weight (pounds):	3773
Occupant + Cargo Weight (pounds):	218
Total Weight (pounds):	3991
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	2.0
Energy Crush Depth (inches):	8.84
Damage Length (inches):	100.0
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2904.73

		Equal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00	20.00	50.00	1.67	83.33	13.33	666.67
C2 (inches)	5.00	20.00	207.00	5.64	1166.63	31.72	6566.67
C3 (inches)	15.70	20.00	320.00	8.00	2560.30	50.06	16020.00
C4 (inches)	16.30	20.00	235.00	6.17	1449.63	68.71	16146.67
C5 (inches)	7.20	20.00	72.00	2.40	172.80	86.67	6240.00
C6 (inches)	0.00						
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 8.84

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	bsub1
Minimum	55.2	23.7	13254.78	15348.68	10.7	10.5	15.2
Avg - 2 Std. Deviations	44.8	15.6	9155.16	10916.41	9.1	9.1	12.3
Avg - 1 Std. Deviations	56.2	24.7	13705.44	15833.58	10.9	10.7	15.4
Average	65.9	33.9	18255.72	20711.14	12.5	12.1	18.1
Avg + 1 Std. Deviations	74.4	43.2	22806.00	25563.22	13.9	13.4	20.4
Avg + 2 Std. Deviations	82.1	52.6	27356.28	30397.13	15.1	14.6	22.6
Maximum	82.4	53.0	27565.23	30618.74	15.2	14.6	22.6

Damage Centroid Depth (x) (inches)	6.15	k^2	3374.76
Damage Centroid Depth (y) (inches)	51.63	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	884.00		

2006 CHEVROLET IMPALA MSP POLICE PACKAGE - Front Impact

Curb Weight (pounds):	3725
Occupant + Cargo Weight (pounds):	39
Total Weight (pounds):	3764
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	5.0
Energy Crush Depth (inches):	7.36
Damage Length (inches):	52.5
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2670.92

"Known" Stiffness Values

	A	B
Average	256.8	59.6
Minimum	207.6	40.4
Maximum	340.6	96.4
Std. Devation	41.6	17.9

		Equal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00						
C2 (inches)	6.70	10.50	35.18	2.23	78.56	7.00	246.23
C3 (inches)	12.70	10.50	101.85	5.00	509.72	16.29	1659.26
C4 (inches)	10.60	10.50	122.33	5.84	714.47	26.09	3191.74
C5 (inches)	6.80	10.50	91.35	4.42	403.69	36.37	3322.20
C6 (inches)	0.00	10.50	35.70	2.27	80.92	45.50	1624.35
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 7.36

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)
Minimum	207.6	40.4	13254.78	15035.75	10.9	11.2	21.7
Avg - 2 Std. Deviations	173.6	23.8	9155.16	11904.80	9.7	9.7	18.8
Avg - 1 Std. Deviations	215.2	41.7	13705.44	15569.91	11.1	11.3	22.0
Average	256.8	59.6	18255.72	19566.62	12.5	12.8	24.9
Avg + 1 Std. Deviations	298.4	77.5	22806.00	23665.16	13.7	14.2	27.6
Avg + 2 Std. Deviations	340.0	95.4	27356.28	27808.21	14.9	15.4	30.0
Maximum	340.6	96.4	27565.23	27958.25	14.9	15.5	30.1

Damage Centroid Depth (x) (inches)	4.63	k^2	3290.26
Damage Centroid Depth (y) (inches)	25.99	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	386.40		

1995 CADILLAC ELDORADO - Side Impact

Curb Weight (pounds):	3773
Occupant + Cargo Weight (pounds):	218
Total Weight (pounds):	3991
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	2.0
Energy Crush Depth (inches):	8.84
Damage Length (inches):	100.0
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2904.73

		Equal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00						
C2 (inches)	5.00	20.00	50.00	1.67	83.33	13.33	666.67
C3 (inches)	15.70	20.00	207.00	5.64	1166.63	31.72	6566.67
C4 (inches)	16.30	20.00	320.00	8.00	2560.30	50.06	16020.00
C5 (inches)	7.20	20.00	235.00	6.17	1449.63	68.71	16146.67
C6 (inches)	0.00	20.00	72.00	2.40	172.80	86.67	6240.00
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 8.84

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	bsub1
Minimum	55.2	23.7	13254.78	15348.68	10.7	10.5	15.2
Avg - 2 Std. Deviations	44.8	15.6	9155.16	10916.41	9.1	9.1	12.3
Avg - 1 Std. Deviations	56.2	24.7	13705.44	15833.58	10.9	10.7	15.4
Average	65.9	33.9	18255.72	20711.14	12.5	12.1	18.1
Avg + 1 Std. Deviations	74.4	43.2	22806.00	25563.22	13.9	13.4	20.4
Avg + 2 Std. Deviations	82.1	52.6	27356.28	30397.13	15.1	14.6	22.6
Maximum	82.4	53.0	27565.23	30618.74	15.2	14.6	22.6

Damage Centroid Depth (x) (inches)	6.15	k^2	3374.76
Damage Centroid Depth (y) (inches)	51.63	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	884.00		

APPENDIX 3

Crush Length = OPTION 1

Impala Stiffness Values from NHTSA Tests = MAXIMUM CRUSH

Crush Measurement Spacing = NON-EQUAL

Lever Arm and Angle = NO

Page 1 = "KNOWN" = Bullet
Page 2 = "UNKNOWN" = Target
Page 3 = The two pages combined onto 1

2006 CHEVROLET IMPALA MSP POLICE PACKAGE - Front Impact

Curb Weight (pounds):	3725
Occupant + Cargo Weight (pounds):	39
Total Weight (pounds):	3764
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	5.0
Energy Crush Depth (inches):	6.65
Damage Length (inches):	52.3
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2670.92

"Known" Stiffness Values

	A	B
Average	256.8	59.6
Minimum	207.6	40.4
Maximum	340.6	96.4
Std. Devation	41.6	17.9

		Unequal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00	17.70	84.96	3.20	271.87	11.80	1002.53
C2 (inches)	9.60	4.60	50.37	5.50	277.17	6.99	352.31
C3 (inches)	12.30	10.70	114.49	5.39	617.09	26.48	3032.08
C4 (inches)	9.10	12.20	82.35	3.51	289.16	41.99	3458.05
C5 (inches)	4.40	7.10	15.62	1.47	22.91	30.77	480.58
C6 (inches)	0.00						
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 6.65

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)
Minimum	207.6	40.4	12454.20	13318.06	10.3	11.8	23.0
Avg - 2 Std. Deviations	173.6	23.8	8678.40	10722.52	9.2	10.2	19.9
Avg - 1 Std. Deviations	215.2	41.7	12879.01	13793.92	10.5	12.0	23.3
Average	256.8	59.6	17079.61	17195.65	11.7	13.6	26.4
Avg + 1 Std. Deviations	298.4	77.5	21280.22	20698.82	12.8	15.0	29.2
Avg + 2 Std. Deviations	340.0	95.4	25480.82	24246.34	13.9	16.4	31.8
Maximum	340.6	96.4	25670.41	24368.75	13.9	16.4	31.9

Damage Centroid Depth (x) (inches)	4.25	k^2	3290.26
Damage Centroid Depth (y) (inches)	23.94	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	347.79		

1995 CADILLAC ELDORADO - Side Impact

Curb Weight (pounds):	3773
Occupant + Cargo Weight (pounds):	218
Total Weight (pounds):	3991
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	2.0
Energy Crush Depth (inches):	13.12
Damage Length (inches):	100.4
Crush Profile Measurements:	8

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2904.73

		Unequal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00	19.80	108.90	3.67	399.30	13.20	1437.48
C2 (inches)	11.00	1.30	13.85	5.33	73.75	1.94	26.90
C3 (inches)	10.30	10.90	188.57	9.12	1720.15	27.99	5277.14
C4 (inches)	24.30	17.20	413.66	12.03	4974.44	60.17	24890.01
C5 (inches)	23.80	9.60	210.72	11.00	2318.13	43.07	9074.69
C6 (inches)	20.10	10.60	176.49	8.44	1490.31	57.93	10224.76
C7 (inches)	13.20	31.00	204.60	4.40	900.24	196.33	40169.80
C8 (inches)	0.00						
C9 (inches)							
C10 (inches)							

Average Crush (inches): 13.12

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	bsub1
Minimum	44.5	15.5	12454.20	20774.50	12.5	11.1	12.3
Avg - 2 Std. Deviations	36.4	10.4	8678.40	14823.96	10.6	9.6	10.0
Avg - 1 Std. Deviations	45.3	16.1	12879.01	21441.20	12.7	11.3	12.5
Average	52.9	21.9	17079.61	28011.96	14.5	12.8	14.6
Avg + 1 Std. Deviations	59.5	27.8	21280.22	34552.63	16.1	14.2	16.4
Avg + 2 Std. Deviations	65.6	33.7	25480.82	41071.77	17.6	15.4	18.1
Maximum	65.8	34.0	25670.41	41365.59	17.6	15.5	18.2

Damage Centroid Depth (x) (inches)	9.02	k^2	3374.76
Damage Centroid Depth (y) (inches)	69.18	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	1316.79		

2006 CHEVROLET IMPALA MSP POLICE PACKAGE - Front Impact

Curb Weight (pounds):	3725
Occupant + Cargo Weight (pounds):	39
Total Weight (pounds):	3764
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	5.0
Energy Crush Depth (inches):	6.65
Damage Length (inches):	52.3
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2670.92

"Known" Stiffness Values

	A	B
Average	256.8	59.6
Minimum	207.6	40.4
Maximum	340.6	96.4
Std. Devation	41.6	17.9

		Unequal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00						
C2 (inches)	9.60	17.70	84.96	3.20	271.87	11.80	1002.53
C3 (inches)	12.30	4.60	50.37	5.50	277.17	6.99	352.31
C4 (inches)	9.10	10.70	114.49	5.39	617.09	26.48	3032.08
C5 (inches)	4.40	12.20	82.35	3.51	289.16	41.99	3458.05
C6 (inches)	0.00	7.10	15.62	1.47	22.91	30.77	480.58
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 6.65

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)
Minimum	207.6	40.4	12454.20	13318.06	10.3	11.8	23.0
Avg - 2 Std. Deviations	173.6	23.8	8678.40	10722.52	9.2	10.2	19.9
Avg - 1 Std. Deviations	215.2	41.7	12879.01	13793.92	10.5	12.0	23.3
Average	256.8	59.6	17079.61	17195.65	11.7	13.6	26.4
Avg + 1 Std. Deviations	298.4	77.5	21280.22	20698.82	12.8	15.0	29.2
Avg + 2 Std. Deviations	340.0	95.4	25480.82	24246.34	13.9	16.4	31.8
Maximum	340.6	96.4	25670.41	24368.75	13.9	16.4	31.9

Damage Centroid Depth (x) (inches)	4.25	k^2	3290.26
Damage Centroid Depth (y) (inches)	23.94	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	347.79		

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Registered Owner: 4N6XPRT SYSTEMS
Serial Number: 15R-030201SC02301

1995 CADILLAC ELDORADO - Side Impact

Curb Weight (pounds):	3773
Occupant + Cargo Weight (pounds):	218
Total Weight (pounds):	3991
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	2.0
Energy Crush Depth (inches):	13.12
Damage Length (inches):	100.4
Crush Profile Measurements:	8

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2904.73

		Unequal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00						
C2 (inches)	11.00	19.80	108.90	3.67	399.30	13.20	1437.48
C3 (inches)	10.30	1.30	13.85	5.33	73.75	1.94	26.90
C4 (inches)	24.30	10.90	188.57	9.12	1720.15	27.99	5277.14
C5 (inches)	23.80	17.20	413.66	12.03	4974.44	60.17	24890.01
C6 (inches)	20.10	9.60	210.72	11.00	2318.13	43.07	9074.69
C7 (inches)	13.20	10.60	176.49	8.44	1490.31	57.93	10224.76
C8 (inches)	0.00	31.00	204.60	4.40	900.24	196.33	40169.80
C9 (inches)							
C10 (inches)							

Average Crush (inches): 13.12

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	bsub1
Minimum	44.5	15.5	12454.20	20774.50	12.5	11.1	12.3
Avg - 2 Std. Deviations	36.4	10.4	8678.40	14823.96	10.6	9.6	10.0
Avg - 1 Std. Deviations	45.3	16.1	12879.01	21441.20	12.7	11.3	12.5
Average	52.9	21.9	17079.61	28011.96	14.5	12.8	14.6
Avg + 1 Std. Deviations	59.5	27.8	21280.22	34552.63	16.1	14.2	16.4
Avg + 2 Std. Deviations	65.6	33.7	25480.82	41071.77	17.6	15.4	18.1
Maximum	65.8	34.0	25670.41	41365.59	17.6	15.5	18.2

Damage Centroid Depth (x) (inches)	9.02	k^2	3374.76
Damage Centroid Depth (y) (inches)	69.18	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	1316.79		

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APPENDIX 3

Crush Length = OPTION 2

Impala Stiffness Values from NHTSA Tests = MAXIMUM CRUSH

Crush Measurement Spacing = EQUAL

Lever Arm and Angle = NO

Page 1 = "KNOWN" = Bullet
Page 2 = "UNKNOWN" = Target
Page 3 = The two pages combined onto 1

2006 CHEVROLET IMPALA MSP POLICE PACKAGE - Front Impact

Curb Weight (pounds):	3725
Occupant + Cargo Weight (pounds):	39
Total Weight (pounds):	3764
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	5.0
Energy Crush Depth (inches):	7.36
Damage Length (inches):	52.5
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2670.92

"Known" Stiffness Values

	A	B
Average	256.8	59.6
Minimum	207.6	40.4
Maximum	340.6	96.4
Std. Devation	41.6	17.9

		Equal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00	10.50	35.18	2.23	78.56	7.00	246.23
C2 (inches)	6.70	10.50	101.85	5.00	509.72	16.29	1659.26
C3 (inches)	12.70	10.50	122.33	5.84	714.47	26.09	3191.74
C4 (inches)	10.60	10.50	91.35	4.42	403.69	36.37	3322.20
C5 (inches)	6.80	10.50	35.70	2.27	80.92	45.50	1624.35
C6 (inches)	0.00						
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 7.36

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)
Minimum	207.6	40.4	13254.78	15035.75	10.9	14.3	27.8
Avg - 2 Std. Deviations	173.6	23.8	9155.16	11904.80	9.7	12.2	23.7
Avg - 1 Std. Deviations	215.2	41.7	13705.44	15569.91	11.1	14.6	28.3
Average	256.8	59.6	18255.72	19566.62	12.5	16.6	32.3
Avg + 1 Std. Deviations	298.4	77.5	22806.00	23665.16	13.7	18.4	35.8
Avg + 2 Std. Deviations	340.0	95.4	27356.28	27808.21	14.9	20.1	39.1
Maximum	340.6	96.4	27565.23	27958.25	14.9	20.2	39.2

Damage Centroid Depth (x) (inches)	4.63	k^2	3290.26
Damage Centroid Depth (y) (inches)	25.99	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	386.40		

1995 CADILLAC ELDORADO - Side Impact

Curb Weight (pounds):	3773
Occupant + Cargo Weight (pounds):	218
Total Weight (pounds):	3991
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	2.0
Energy Crush Depth (inches):	19.56
Damage Length (inches):	156.0
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2904.73

		Equal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00	31.20	845.52	18.07	15275.73	20.80	17586.82
C2 (inches)	54.20	31.20	1127.88	19.58	22080.60	44.20	49856.35
C3 (inches)	18.10	31.20	577.20	9.25	5339.93	78.11	45086.50
C4 (inches)	18.90	31.20	397.80	6.87	2732.65	106.69	42441.98
C5 (inches)	6.60	31.20	102.96	2.20	226.51	135.20	13920.19
C6 (inches)	0.00						
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 19.56

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	bsub1
Minimum	24.7	7.4	13254.78	35063.44	16.2	13.5	10.6
Avg - 2 Std. Deviations	20.2	5.0	9155.16	24571.46	13.6	11.5	8.7
Avg - 1 Std. Deviations	25.1	7.7	13705.44	36214.09	16.5	13.7	10.8
Average	29.3	10.5	18255.72	47810.77	19.0	15.7	12.6
Avg + 1 Std. Deviations	33.0	13.3	22806.00	59377.98	21.1	17.4	14.1
Avg + 2 Std. Deviations	36.3	16.1	27356.28	70924.20	23.1	19.0	15.6
Maximum	36.5	16.2	27565.23	71453.99	23.2	19.0	15.6

Damage Centroid Depth (x) (inches)	14.96	k^2	3374.76
Damage Centroid Depth (y) (inches)	55.35	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	3051.36		

2006 CHEVROLET IMPALA MSP POLICE PACKAGE - Front Impact

Curb Weight (pounds):	3725
Occupant + Cargo Weight (pounds):	39
Total Weight (pounds):	3764
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	5.0
Energy Crush Depth (inches):	7.36
Damage Length (inches):	52.5
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2670.92

"Known" Stiffness Values

	A	B
Average	256.8	59.6
Minimum	207.6	40.4
Maximum	340.6	96.4
Std. Devation	41.6	17.9

		Equal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00						
C2 (inches)	6.70	10.50	35.18	2.23	78.56	7.00	246.23
C3 (inches)	12.70	10.50	101.85	5.00	509.72	16.29	1659.26
C4 (inches)	10.60	10.50	122.33	5.84	714.47	26.09	3191.74
C5 (inches)	6.80	10.50	91.35	4.42	403.69	36.37	3322.20
C6 (inches)	0.00	10.50	35.70	2.27	80.92	45.50	1624.35
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 7.36

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)
Minimum	207.6	40.4	13254.78	15035.75	10.9	14.3	27.8
Avg - 2 Std. Deviations	173.6	23.8	9155.16	11904.80	9.7	12.2	23.7
Avg - 1 Std. Deviations	215.2	41.7	13705.44	15569.91	11.1	14.6	28.3
Average	256.8	59.6	18255.72	19566.62	12.5	16.6	32.3
Avg + 1 Std. Deviations	298.4	77.5	22806.00	23665.16	13.7	18.4	35.8
Avg + 2 Std. Deviations	340.0	95.4	27356.28	27808.21	14.9	20.1	39.1
Maximum	340.6	96.4	27565.23	27958.25	14.9	20.2	39.2

Damage Centroid Depth (x) (inches)	4.63	k^2	3290.26
Damage Centroid Depth (y) (inches)	25.99	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	386.40		

1995 CADILLAC ELDORADO - Side Impact

Curb Weight (pounds):	3773
Occupant + Cargo Weight (pounds):	218
Total Weight (pounds):	3991
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	2.0
Energy Crush Depth (inches):	19.56
Damage Length (inches):	156.0
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2904.73

		Equal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00						
C2 (inches)	54.20	31.20	845.52	18.07	15275.73	20.80	17586.82
C3 (inches)	18.10	31.20	1127.88	19.58	22080.60	44.20	49856.35
C4 (inches)	18.90	31.20	577.20	9.25	5339.93	78.11	45086.50
C5 (inches)	6.60	31.20	397.80	6.87	2732.65	106.69	42441.98
C6 (inches)	0.00	31.20	102.96	2.20	226.51	135.20	13920.19
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 19.56

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	bsub1
Minimum	24.7	7.4	13254.78	35063.44	16.2	13.5	10.6
Avg - 2 Std. Deviations	20.2	5.0	9155.16	24571.46	13.6	11.5	8.7
Avg - 1 Std. Deviations	25.1	7.7	13705.44	36214.09	16.5	13.7	10.8
Average	29.3	10.5	18255.72	47810.77	19.0	15.7	12.6
Avg + 1 Std. Deviations	33.0	13.3	22806.00	59377.98	21.1	17.4	14.1
Avg + 2 Std. Deviations	36.3	16.1	27356.28	70924.20	23.1	19.0	15.6
Maximum	36.5	16.2	27565.23	71453.99	23.2	19.0	15.6

Damage Centroid Depth (x) (inches)	14.96	k^2	3374.76
Damage Centroid Depth (y) (inches)	55.35	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	3051.36		

APPENDIX 3

Crush Length = OPTION 2

Impala Stiffness Values from NHTSA Tests = MAXIMUM CRUSH

Crush Measurement Spacing = NON-EQUAL

Lever Arm and Angle = NO

Page 1 = “KNOWN” = Bullet
Page 2 = “UNKNOWN” = Target
Page 3 = The two pages combined onto 1

2006 CHEVROLET IMPALA MSP POLICE PACKAGE - Front Impact

Curb Weight (pounds):	3725
Occupant + Cargo Weight (pounds):	39
Total Weight (pounds):	3764
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	5.0
Energy Crush Depth (inches):	6.65
Damage Length (inches):	52.3
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2670.92

"Known" Stiffness Values

	A	B
Average	256.8	59.6
Minimum	207.6	40.4
Maximum	340.6	96.4
Std. Devation	41.6	17.9

		Unequal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00	17.70	84.96	3.20	271.87	11.80	1002.53
C2 (inches)	9.60	4.60	50.37	5.50	277.17	6.99	352.31
C3 (inches)	12.30	10.70	114.49	5.39	617.09	26.48	3032.08
C4 (inches)	9.10	12.20	82.35	3.51	289.16	41.99	3458.05
C5 (inches)	4.40	7.10	15.62	1.47	22.91	30.77	480.58
C6 (inches)	0.00						
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 6.65

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)
Minimum	207.6	40.4	12454.20	13318.06	10.3	11.1	21.6
Avg - 2 Std. Deviations	173.6	23.8	8678.40	10722.52	9.2	9.7	18.8
Avg - 1 Std. Deviations	215.2	41.7	12879.01	13793.92	10.5	11.3	22.0
Average	256.8	59.6	17079.61	17195.65	11.7	12.8	24.9
Avg + 1 Std. Deviations	298.4	77.5	21280.22	20698.82	12.8	14.1	27.5
Avg + 2 Std. Deviations	340.0	95.4	25480.82	24246.34	13.9	15.4	29.9
Maximum	340.6	96.4	25670.41	24368.75	13.9	15.4	30.0

Damage Centroid Depth (x) (inches)	4.25	k^2	3290.26
Damage Centroid Depth (y) (inches)	23.94	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	347.79		

1995 CADILLAC ELDORADO - Side Impact

Curb Weight (pounds):	3773
Occupant + Cargo Weight (pounds):	218
Total Weight (pounds):	3991
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	2.0
Energy Crush Depth (inches):	9.61
Damage Length (inches):	155.9
Crush Profile Measurements:	10

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2904.73

		Unequal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00	29.30	68.86	1.57	107.87	19.53	1344.97
C2 (inches)	4.70	18.30	130.85	3.71	486.08	28.50	3728.44
C3 (inches)	9.60	1.30	11.96	4.60	55.05	3.24	38.76
C4 (inches)	8.80	10.60	147.34	7.26	1069.96	37.75	5561.82
C5 (inches)	19.00	8.60	172.43	10.03	1730.19	38.78	6685.98
C6 (inches)	21.10	18.10	377.39	10.43	3934.43	99.51	37555.03
C7 (inches)	20.60	10.80	196.02	9.13	1789.69	69.96	13712.98
C8 (inches)	15.70	33.60	337.68	5.55	1875.61	248.85	84032.26
C9 (inches)	4.40	25.30	55.66	1.47	81.63	210.83	11734.98
C10 (inches)	0.00						

Average Crush (inches): 9.61

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	bsub1
Minimum	32.9	13.2	12454.20	16887.68	11.3	10.5	14.1
Avg - 2 Std. Deviations	26.9	8.8	8678.40	12040.79	9.5	9.1	11.5
Avg - 1 Std. Deviations	33.6	13.7	12879.01	17431.27	11.4	10.7	14.4
Average	39.2	18.7	17079.61	22793.02	13.1	12.1	16.8
Avg + 1 Std. Deviations	44.2	23.8	21280.22	28136.14	14.5	13.3	18.9
Avg + 2 Std. Deviations	48.8	28.9	25480.82	33465.93	15.9	14.5	20.9
Maximum	49.0	29.2	25670.41	33706.22	15.9	14.5	21.0

Damage Centroid Depth (x) (inches)	7.43	k^2	3374.76
Damage Centroid Depth (y) (inches)	109.73	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	1498.18		

2006 CHEVROLET IMPALA MSP POLICE PACKAGE - Front Impact

Curb Weight (pounds):	3725
Occupant + Cargo Weight (pounds):	39
Total Weight (pounds):	3764
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	5.0
Energy Crush Depth (inches):	6.65
Damage Length (inches):	52.3
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2670.92

"Known" Stiffness Values

	A	B
Average	256.8	59.6
Minimum	207.6	40.4
Maximum	340.6	96.4
Std. Devation	41.6	17.9

	Unequal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches) 0.00						
C2 (inches) 9.60	17.70	84.96	3.20	271.87	11.80	1002.53
C3 (inches) 12.30	4.60	50.37	5.50	277.17	6.99	352.31
C4 (inches) 9.10	10.70	114.49	5.39	617.09	26.48	3032.08
C5 (inches) 4.40	12.20	82.35	3.51	289.16	41.99	3458.05
C6 (inches) 0.00	7.10	15.62	1.47	22.91	30.77	480.58
C7 (inches)						
C8 (inches)						
C9 (inches)						
C10 (inches)						

Average Crush (inches): 6.65

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)
Minimum	207.6	40.4	12454.20	13318.06	10.3	11.1	21.6
Avg - 2 Std. Deviations	173.6	23.8	8678.40	10722.52	9.2	9.7	18.8
Avg - 1 Std. Deviations	215.2	41.7	12879.01	13793.92	10.5	11.3	22.0
Average	256.8	59.6	17079.61	17195.65	11.7	12.8	24.9
Avg + 1 Std. Deviations	298.4	77.5	21280.22	20698.82	12.8	14.1	27.5
Avg + 2 Std. Deviations	340.0	95.4	25480.82	24246.34	13.9	15.4	29.9
Maximum	340.6	96.4	25670.41	24368.75	13.9	15.4	30.0

Damage Centroid Depth (x) (inches)	4.25	k^2	3290.26
Damage Centroid Depth (y) (inches)	23.94	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	347.79		

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1995 CADILLAC ELDORADO - Side Impact

Curb Weight (pounds):	3773
Occupant + Cargo Weight (pounds):	218
Total Weight (pounds):	3991
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	2.0
Energy Crush Depth (inches):	9.61
Damage Length (inches):	155.9
Crush Profile Measurements:	10

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2904.73

	Unequal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches) 0.00						
C2 (inches) 4.70	29.30	68.86	1.57	107.87	19.53	1344.97
C3 (inches) 9.60	18.30	130.85	3.71	486.08	28.50	3728.44
C4 (inches) 8.80	1.30	11.96	4.60	55.05	3.24	38.76
C5 (inches) 19.00	10.60	147.34	7.26	1069.96	37.75	5561.82
C6 (inches) 21.10	8.60	172.43	10.03	1730.19	38.78	6685.98
C7 (inches) 20.60	18.10	377.39	10.43	3934.43	99.51	37555.03
C8 (inches) 15.70	10.80	196.02	9.13	1789.69	69.96	13712.98
C9 (inches) 4.40	33.60	337.68	5.55	1875.61	248.85	84032.26
C10 (inches) 0.00	25.30	55.66	1.47	81.63	210.83	11734.98

Average Crush (inches): 9.61

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	bsub1
Minimum	32.9	13.2	12454.20	16887.68	11.3	10.5	14.1
Avg - 2 Std. Deviations	26.9	8.8	8678.40	12040.79	9.5	9.1	11.5
Avg - 1 Std. Deviations	33.6	13.7	12879.01	17431.27	11.4	10.7	14.4
Average	39.2	18.7	17079.61	22793.02	13.1	12.1	16.8
Avg + 1 Std. Deviations	44.2	23.8	21280.22	28136.14	14.5	13.3	18.9
Avg + 2 Std. Deviations	48.8	28.9	25480.82	33465.93	15.9	14.5	20.9
Maximum	49.0	29.2	25670.41	33706.22	15.9	14.5	21.0

Damage Centroid Depth (x) (inches)	7.43	k^2	3374.76
Damage Centroid Depth (y) (inches)	109.73	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	1498.18		

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APPENDIX 3

Crush Length = OPTION 1

Impala Stiffness Values from NHTSA Tests = MAXIMUM CRUSH

Crush Measurement Spacing = EQUAL

Lever Arm and Angle = YES

Page 1 = "KNOWN" = Bullet
Page 2 = "UNKNOWN" = Target
Page 3 = The two pages combined onto 1

2006 CHEVROLET IMPALA MSP POLICE PACKAGE - Front Impact

Curb Weight (pounds):	3725
Occupant + Cargo Weight (pounds):	39
Total Weight (pounds):	3764
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	5.0
Energy Crush Depth (inches):	7.36
Damage Length (inches):	52.5
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2670.92

"Known" Stiffness Values

	A	B
Average	256.8	59.6
Minimum	207.6	40.4
Maximum	340.6	96.4
Std. Devation	41.6	17.9

		Equal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00	10.50	35.18	2.23	78.56	7.00	246.23
C2 (inches)	6.70	10.50	101.85	5.00	509.72	16.29	1659.26
C3 (inches)	12.70	10.50	122.33	5.84	714.47	26.09	3191.74
C4 (inches)	10.60	10.50	91.35	4.42	403.69	36.37	3322.20
C5 (inches)	6.80	10.50	35.70	2.27	80.92	45.50	1624.35
C6 (inches)	0.00						
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 7.36

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)
Minimum	207.6	40.4	13254.78	15035.75	10.9	11.0	23.8
Avg - 2 Std. Deviations	173.6	23.8	9155.16	11904.80	9.7	9.5	20.6
Avg - 1 Std. Deviations	215.2	41.7	13705.44	15569.91	11.1	11.2	24.2
Average	256.8	59.6	18255.72	19566.62	12.5	12.7	27.5
Avg + 1 Std. Deviations	298.4	77.5	22806.00	23665.16	13.7	14.0	30.4
Avg + 2 Std. Deviations	340.0	95.4	27356.28	27808.21	14.9	15.2	33.0
Maximum	340.6	96.4	27565.23	27958.25	14.9	15.3	33.1

Damage Centroid Depth (x) (inches)	4.63	k^2	3290.26
Damage Centroid Depth (y) (inches)	25.99	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	386.40		

1995 CADILLAC ELDORADO - Side Impact

Curb Weight (pounds):	3773
Occupant + Cargo Weight (pounds):	218
Total Weight (pounds):	3991
Angle Coll Force to Normal (degrees):	30.0
No Damage Speed (mph):	2.0
Energy Crush Depth (inches):	8.84
Damage Length (inches):	100.0
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	28.50
Yaw Moment of Inertia (lb-ft-sec^2)	2904.73

		Equal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00	20.00	50.00	1.67	83.33	13.33	666.67
C2 (inches)	5.00	20.00	207.00	5.64	1166.63	31.72	6566.67
C3 (inches)	15.70	20.00	320.00	8.00	2560.30	50.06	16020.00
C4 (inches)	16.30	20.00	235.00	6.17	1449.63	68.71	16146.67
C5 (inches)	7.20	20.00	72.00	2.40	172.80	86.67	6240.00
C6 (inches)	0.00						
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 8.84

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	bsub1
Minimum	50.9	20.2	13254.78	17911.88	11.6	10.4	14.0
Avg - 2 Std. Deviations	41.2	13.3	9155.16	12774.23	9.8	9.0	11.3
Avg - 1 Std. Deviations	51.9	21.0	13705.44	18473.77	11.8	10.5	14.2
Average	60.8	28.9	18255.72	24124.34	13.5	11.9	16.7
Avg + 1 Std. Deviations	68.8	36.9	22806.00	29743.35	15.0	13.2	18.9
Avg + 2 Std. Deviations	75.9	45.0	27356.28	35339.86	16.3	14.3	20.9
Maximum	76.3	45.4	27565.23	35596.41	16.4	14.4	21.0

Damage Centroid Depth (x) (inches)	6.15	k^2	3374.76
Damage Centroid Depth (y) (inches)	51.63	Eff. Mass Ratio (gamma)	0.81
Area of Damage (inches^2):	884.00		

2006 CHEVROLET IMPALA MSP POLICE PACKAGE - Front Impact

Curb Weight (pounds):	3725
Occupant + Cargo Weight (pounds):	39
Total Weight (pounds):	3764
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	5.0
Energy Crush Depth (inches):	7.36
Damage Length (inches):	52.5
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2670.92

"Known" Stiffness Values

	A	B
Average	256.8	59.6
Minimum	207.6	40.4
Maximum	340.6	96.4
Std. Devation	41.6	17.9

		Equal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00						
C2 (inches)	6.70	10.50	35.18	2.23	78.56	7.00	246.23
C3 (inches)	12.70	10.50	101.85	5.00	509.72	16.29	1659.26
C4 (inches)	10.60	10.50	122.33	5.84	714.47	26.09	3191.74
C5 (inches)	6.80	10.50	91.35	4.42	403.69	36.37	3322.20
C6 (inches)	0.00	10.50	35.70	2.27	80.92	45.50	1624.35
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 7.36

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)
Minimum	207.6	40.4	13254.78	15035.75	10.9	11.0	23.8
Avg - 2 Std. Deviations	173.6	23.8	9155.16	11904.80	9.7	9.5	20.6
Avg - 1 Std. Deviations	215.2	41.7	13705.44	15569.91	11.1	11.2	24.2
Average	256.8	59.6	18255.72	19566.62	12.5	12.7	27.5
Avg + 1 Std. Deviations	298.4	77.5	22806.00	23665.16	13.7	14.0	30.4
Avg + 2 Std. Deviations	340.0	95.4	27356.28	27808.21	14.9	15.2	33.0
Maximum	340.6	96.4	27565.23	27958.25	14.9	15.3	33.1

Damage Centroid Depth (x) (inches)	4.63	k^2	3290.26
Damage Centroid Depth (y) (inches)	25.99	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	386.40		

1995 CADILLAC ELDORADO - Side Impact

Curb Weight (pounds):	3773
Occupant + Cargo Weight (pounds):	218
Total Weight (pounds):	3991
Angle Coll Force to Normal (degrees):	30.0
No Damage Speed (mph):	2.0
Energy Crush Depth (inches):	8.84
Damage Length (inches):	100.0
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	28.50
Yaw Moment of Inertia (lb-ft-sec^2)	2904.73

		Equal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00						
C2 (inches)	5.00	20.00	50.00	1.67	83.33	13.33	666.67
C3 (inches)	15.70	20.00	207.00	5.64	1166.63	31.72	6566.67
C4 (inches)	16.30	20.00	320.00	8.00	2560.30	50.06	16020.00
C5 (inches)	7.20	20.00	235.00	6.17	1449.63	68.71	16146.67
C6 (inches)	0.00	20.00	72.00	2.40	172.80	86.67	6240.00
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 8.84

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	bsub1
Minimum	50.9	20.2	13254.78	17911.88	11.6	10.4	14.0
Avg - 2 Std. Deviations	41.2	13.3	9155.16	12774.23	9.8	9.0	11.3
Avg - 1 Std. Deviations	51.9	21.0	13705.44	18473.77	11.8	10.5	14.2
Average	60.8	28.9	18255.72	24124.34	13.5	11.9	16.7
Avg + 1 Std. Deviations	68.8	36.9	22806.00	29743.35	15.0	13.2	18.9
Avg + 2 Std. Deviations	75.9	45.0	27356.28	35339.86	16.3	14.3	20.9
Maximum	76.3	45.4	27565.23	35596.41	16.4	14.4	21.0

Damage Centroid Depth (x) (inches)	6.15	k^2	3374.76
Damage Centroid Depth (y) (inches)	51.63	Eff. Mass Ratio (gamma)	0.81
Area of Damage (inches^2):	884.00		

APPENDIX 3

Crush Length = OPTION 1

Impala Stiffness Values from NHTSA Tests = MAXIMUM CRUSH

Crush Measurement Spacing = NON-EQUAL

Lever Arm and Angle = YES

Page 1 = “KNOWN” = Bullet
Page 2 = “UNKNOWN” = Target
Page 3 = The two pages combined onto 1

2006 CHEVROLET IMPALA MSP POLICE PACKAGE - Front Impact

Curb Weight (pounds):	3725
Occupant + Cargo Weight (pounds):	39
Total Weight (pounds):	3764
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	5.0
Energy Crush Depth (inches):	6.65
Damage Length (inches):	52.3
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2670.92

"Known" Stiffness Values

	A	B
Average	256.8	59.6
Minimum	207.6	40.4
Maximum	340.6	96.4
Std. Devation	41.6	17.9

		Unequal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00	17.70	84.96	3.20	271.87	11.80	1002.53
C2 (inches)	9.60	4.60	50.37	5.50	277.17	6.99	352.31
C3 (inches)	12.30	10.70	114.49	5.39	617.09	26.48	3032.08
C4 (inches)	9.10	12.20	82.35	3.51	289.16	41.99	3458.05
C5 (inches)	4.40	7.10	15.62	1.47	22.91	30.77	480.58
C6 (inches)	0.00						
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 6.65

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)
Minimum	207.6	40.4	12454.10	13318.06	10.3	9.8	21.3
Avg - 2 Std. Deviations	173.6	23.8	8678.34	10722.52	9.2	8.6	18.7
Avg - 1 Std. Deviations	215.2	41.7	12878.90	13793.92	10.5	10.0	21.6
Average	256.8	59.6	17079.46	17195.65	11.7	11.2	24.2
Avg + 1 Std. Deviations	298.4	77.5	21280.02	20698.82	12.8	12.3	26.6
Avg + 2 Std. Deviations	340.0	95.4	25480.58	24246.34	13.9	13.3	28.8
Maximum	340.6	96.4	25670.17	24368.75	13.9	13.3	28.9

Damage Centroid Depth (x) (inches)	4.25	k^2	3290.26
Damage Centroid Depth (y) (inches)	23.94	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	347.79		

1995 CADILLAC ELDORADO - Side Impact

Curb Weight (pounds):	3773
Occupant + Cargo Weight (pounds):	218
Total Weight (pounds):	3991
Angle Coll Force to Normal (degrees):	30.0
No Damage Speed (mph):	2.0
Energy Crush Depth (inches):	30.56
Damage Length (inches):	100.4
Crush Profile Measurements:	8

PDOF

Lever Arm Distance (inches):	28.50
Yaw Moment of Inertia (lb-ft-sec^2)	2904.73

		Unequal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00	19.80	108.90	3.67	399.30	13.20	1437.48
C2 (inches)	11.00	1.30	13.85	5.33	73.75	1.94	26.90
C3 (inches)	10.30	10.90	188.57	9.12	1720.15	27.99	5277.14
C4 (inches)	24.30	17.20	413.66	12.03	4974.44	60.17	24890.01
C5 (inches)	23.80	9.60	210.72	11.00	2318.13	43.07	9074.69
C6 (inches)	20.10	10.60	176.49	8.44	1490.31	57.93	10224.76
C7 (inches)	13.20	31.00	204.60	4.40	900.24	196.33	40169.80
C8 (inches)	0.00						
C9 (inches)							
C10 (inches)							

Average Crush (inches): 13.12

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	bsub1
Minimum	27.9	6.1	12454.10	12870.74	9.8	9.2	7.7
Avg - 2 Std. Deviations	23.0	4.1	8678.34	9548.98	8.5	8.1	6.3
Avg - 1 Std. Deviations	28.4	6.3	12878.90	13239.32	10.0	9.4	7.8
Average	33.1	8.6	17079.46	16843.81	11.3	10.5	9.1
Avg + 1 Std. Deviations	37.1	10.8	21280.02	20392.84	12.4	11.6	10.2
Avg + 2 Std. Deviations	40.8	13.0	25480.58	23902.22	13.4	12.5	11.3
Maximum	41.0	13.2	25670.17	24059.85	13.4	12.6	11.3

Damage Centroid Depth (x) (inches)	9.02	k^2	3374.76
Damage Centroid Depth (y) (inches)	69.18	Eff. Mass Ratio (gamma)	0.81
Area of Damage (inches^2):	1316.79		

2006 CHEVROLET IMPALA MSP POLICE PACKAGE - Front Impact

Curb Weight (pounds):	3725
Occupant + Cargo Weight (pounds):	39
Total Weight (pounds):	3764
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	5.0
Energy Crush Depth (inches):	6.65
Damage Length (inches):	52.3
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2670.92

"Known" Stiffness Values

	A	B
Average	256.8	59.6
Minimum	207.6	40.4
Maximum	340.6	96.4
Std. Devation	41.6	17.9

		Unequal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00						
C2 (inches)	9.60	17.70	84.96	3.20	271.87	11.80	1002.53
C3 (inches)	12.30	4.60	50.37	5.50	277.17	6.99	352.31
C4 (inches)	9.10	10.70	114.49	5.39	617.09	26.48	3032.08
C5 (inches)	4.40	12.20	82.35	3.51	289.16	41.99	3458.05
C6 (inches)	0.00	7.10	15.62	1.47	22.91	30.77	480.58
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 6.65

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)
Minimum	207.6	40.4	12454.10	13318.06	10.3	9.8	21.3
Avg - 2 Std. Deviations	173.6	23.8	8678.34	10722.52	9.2	8.6	18.7
Avg - 1 Std. Deviations	215.2	41.7	12878.90	13793.92	10.5	10.0	21.6
Average	256.8	59.6	17079.46	17195.65	11.7	11.2	24.2
Avg + 1 Std. Deviations	298.4	77.5	21280.02	20698.82	12.8	12.3	26.6
Avg + 2 Std. Deviations	340.0	95.4	25480.58	24246.34	13.9	13.3	28.8
Maximum	340.6	96.4	25670.17	24368.75	13.9	13.3	28.9

Damage Centroid Depth (x) (inches)	4.25	k^2	3290.26
Damage Centroid Depth (y) (inches)	23.94	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	347.79		

1995 CADILLAC ELDORADO - Side Impact

Curb Weight (pounds):	3773
Occupant + Cargo Weight (pounds):	218
Total Weight (pounds):	3991
Angle Coll Force to Normal (degrees):	30.0
No Damage Speed (mph):	2.0
Energy Crush Depth (inches):	30.56
Damage Length (inches):	100.4
Crush Profile Measurements:	8

PDOF

Lever Arm Distance (inches):	28.50
Yaw Moment of Inertia (lb-ft-sec^2)	2904.73

		Unequal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00						
C2 (inches)	11.00	19.80	108.90	3.67	399.30	13.20	1437.48
C3 (inches)	10.30	1.30	13.85	5.33	73.75	1.94	26.90
C4 (inches)	24.30	10.90	188.57	9.12	1720.15	27.99	5277.14
C5 (inches)	23.80	17.20	413.66	12.03	4974.44	60.17	24890.01
C6 (inches)	20.10	9.60	210.72	11.00	2318.13	43.07	9074.69
C7 (inches)	13.20	10.60	176.49	8.44	1490.31	57.93	10224.76
C8 (inches)	0.00	31.00	204.60	4.40	900.24	196.33	40169.80
C9 (inches)							
C10 (inches)							

Average Crush (inches): 13.12

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	bsub1
Minimum	27.9	6.1	12454.10	12870.74	9.8	9.2	7.7
Avg - 2 Std. Deviations	23.0	4.1	8678.34	9548.98	8.5	8.1	6.3
Avg - 1 Std. Deviations	28.4	6.3	12878.90	13239.32	10.0	9.4	7.8
Average	33.1	8.6	17079.46	16843.81	11.3	10.5	9.1
Avg + 1 Std. Deviations	37.1	10.8	21280.02	20392.84	12.4	11.6	10.2
Avg + 2 Std. Deviations	40.8	13.0	25480.58	23902.22	13.4	12.5	11.3
Maximum	41.0	13.2	25670.17	24059.85	13.4	12.6	11.3

Damage Centroid Depth (x) (inches)	9.02	k^2	3374.76
Damage Centroid Depth (y) (inches)	69.18	Eff. Mass Ratio (gamma)	0.81
Area of Damage (inches^2):	1316.79		

APPENDIX 3

Crush Length = OPTION 2

Impala Stiffness Values from NHTSA Tests = MAXIMUM CRUSH

Crush Measurement Spacing = EQUAL

Lever Arm and Angle = YES

Page 1 = "KNOWN" = Bullet
Page 2 = "UNKNOWN" = Target
Page 3 = The two pages combined onto 1

2006 CHEVROLET IMPALA MSP POLICE PACKAGE - Front Impact

Curb Weight (pounds):	3725
Occupant + Cargo Weight (pounds):	39
Total Weight (pounds):	3764
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	5.0
Energy Crush Depth (inches):	7.36
Damage Length (inches):	52.5
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2670.92

"Known" Stiffness Values

	A	B
Average	256.8	59.6
Minimum	207.6	40.4
Maximum	340.6	96.4
Std. Devation	41.6	17.9

		Equal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00	10.50	35.18	2.23	78.56	7.00	246.23
C2 (inches)	6.70	10.50	101.85	5.00	509.72	16.29	1659.26
C3 (inches)	12.70	10.50	122.33	5.84	714.47	26.09	3191.74
C4 (inches)	10.60	10.50	91.35	4.42	403.69	36.37	3322.20
C5 (inches)	6.80	10.50	35.70	2.27	80.92	45.50	1624.35
C6 (inches)	0.00						
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 7.36

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)
Minimum	207.6	40.4	13254.78	15035.75	10.9	14.3	31.0
Avg - 2 Std. Deviations	173.6	23.8	9155.16	11904.80	9.7	12.2	26.4
Avg - 1 Std. Deviations	215.2	41.7	13705.44	15569.91	11.1	14.5	31.5
Average	256.8	59.6	18255.72	19566.62	12.5	16.6	36.0
Avg + 1 Std. Deviations	298.4	77.5	22806.00	23665.16	13.7	18.4	40.0
Avg + 2 Std. Deviations	340.0	95.4	27356.28	27808.21	14.9	20.1	43.6
Maximum	340.6	96.4	27565.23	27958.25	14.9	20.1	43.7

Damage Centroid Depth (x) (inches)	4.63	k^2	3290.26
Damage Centroid Depth (y) (inches)	25.99	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	386.40		

1995 CADILLAC ELDORADO - Side Impact

Curb Weight (pounds):	3773
Occupant + Cargo Weight (pounds):	218
Total Weight (pounds):	3991
Angle Coll Force to Normal (degrees):	30.0
No Damage Speed (mph):	2.0
Energy Crush Depth (inches):	19.56
Damage Length (inches):	156.0
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	28.50
Yaw Moment of Inertia (lb-ft-sec^2)	2904.73

		Equal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00	31.20	845.52	18.07	15275.73	20.80	17586.82
C2 (inches)	54.20	31.20	1127.88	19.58	22080.60	44.20	49856.35
C3 (inches)	18.10	31.20	577.20	9.25	5339.93	78.11	45086.50
C4 (inches)	18.90	31.20	397.80	6.87	2732.65	106.69	42441.98
C5 (inches)	6.60	31.20	102.96	2.20	226.51	135.20	13920.19
C6 (inches)	0.00						
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 19.56

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	bsub1
Minimum	22.8	6.4	13254.78	40699.54	17.5	13.5	9.8
Avg - 2 Std. Deviations	18.7	4.2	9155.16	28561.51	14.7	11.5	8.0
Avg - 1 Std. Deviations	23.3	6.6	13705.44	42030.49	17.8	13.7	10.0
Average	27.1	9.0	18255.72	55442.56	20.4	15.6	11.6
Avg + 1 Std. Deviations	30.6	11.4	22806.00	68818.08	22.7	17.4	13.1
Avg + 2 Std. Deviations	33.7	13.8	27356.28	82167.59	24.9	18.9	14.4
Maximum	33.8	13.9	27565.23	82780.09	24.9	19.0	14.5

Damage Centroid Depth (x) (inches)	14.96	k^2	3374.76
Damage Centroid Depth (y) (inches)	55.35	Eff. Mass Ratio (gamma)	0.81
Area of Damage (inches^2):	3051.36		

2006 CHEVROLET IMPALA MSP POLICE PACKAGE - Front Impact

Curb Weight (pounds):	3725
Occupant + Cargo Weight (pounds):	39
Total Weight (pounds):	3764
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	5.0
Energy Crush Depth (inches):	7.36
Damage Length (inches):	52.5
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2670.92

"Known" Stiffness Values

	A	B
Average	256.8	59.6
Minimum	207.6	40.4
Maximum	340.6	96.4
Std. Devation	41.6	17.9

		Equal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00						
C2 (inches)	6.70	10.50	35.18	2.23	78.56	7.00	246.23
C3 (inches)	12.70	10.50	101.85	5.00	509.72	16.29	1659.26
C4 (inches)	10.60	10.50	122.33	5.84	714.47	26.09	3191.74
C5 (inches)	6.80	10.50	91.35	4.42	403.69	36.37	3322.20
C6 (inches)	0.00	10.50	35.70	2.27	80.92	45.50	1624.35
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 7.36

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)
Minimum	207.6	40.4	13254.78	15035.75	10.9	14.3	31.0
Avg - 2 Std. Deviations	173.6	23.8	9155.16	11904.80	9.7	12.2	26.4
Avg - 1 Std. Deviations	215.2	41.7	13705.44	15569.91	11.1	14.5	31.5
Average	256.8	59.6	18255.72	19566.62	12.5	16.6	36.0
Avg + 1 Std. Deviations	298.4	77.5	22806.00	23665.16	13.7	18.4	40.0
Avg + 2 Std. Deviations	340.0	95.4	27356.28	27808.21	14.9	20.1	43.6
Maximum	340.6	96.4	27565.23	27958.25	14.9	20.1	43.7

Damage Centroid Depth (x) (inches)	4.63	k^2	3290.26
Damage Centroid Depth (y) (inches)	25.99	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	386.40		

1995 CADILLAC ELDORADO - Side Impact

Curb Weight (pounds):	3773
Occupant + Cargo Weight (pounds):	218
Total Weight (pounds):	3991
Angle Coll Force to Normal (degrees):	30.0
No Damage Speed (mph):	2.0
Energy Crush Depth (inches):	19.56
Damage Length (inches):	156.0
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	28.50
Yaw Moment of Inertia (lb-ft-sec^2)	2904.73

		Equal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00						
C2 (inches)	54.20	31.20	845.52	18.07	15275.73	20.80	17586.82
C3 (inches)	18.10	31.20	1127.88	19.58	22080.60	44.20	49856.35
C4 (inches)	18.90	31.20	577.20	9.25	5339.93	78.11	45086.50
C5 (inches)	6.60	31.20	397.80	6.87	2732.65	106.69	42441.98
C6 (inches)	0.00	31.20	102.96	2.20	226.51	135.20	13920.19
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 19.56

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	bsub1
Minimum	22.8	6.4	13254.78	40699.54	17.5	13.5	9.8
Avg - 2 Std. Deviations	18.7	4.2	9155.16	28561.51	14.7	11.5	8.0
Avg - 1 Std. Deviations	23.3	6.6	13705.44	42030.49	17.8	13.7	10.0
Average	27.1	9.0	18255.72	55442.56	20.4	15.6	11.6
Avg + 1 Std. Deviations	30.6	11.4	22806.00	68818.08	22.7	17.4	13.1
Avg + 2 Std. Deviations	33.7	13.8	27356.28	82167.59	24.9	18.9	14.4
Maximum	33.8	13.9	27565.23	82780.09	24.9	19.0	14.5

Damage Centroid Depth (x) (inches)	14.96	k^2	3374.76
Damage Centroid Depth (y) (inches)	55.35	Eff. Mass Ratio (gamma)	0.81
Area of Damage (inches^2):	3051.36		

APPENDIX 3

Crush Length = OPTION 2

Impala Stiffness Values from NHTSA Tests = MAXIMUM CRUSH

Crush Measurement Spacing = NON-EQUAL

Lever Arm and Angle = YES

Page 1 = “KNOWN” = Bullet
Page 2 = “UNKNOWN” = Target
Page 3 = The two pages combined onto 1

2006 CHEVROLET IMPALA MSP POLICE PACKAGE - Front Impact

Curb Weight (pounds):	3725
Occupant + Cargo Weight (pounds):	39
Total Weight (pounds):	3764
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	5.0
Energy Crush Depth (inches):	6.65
Damage Length (inches):	52.3
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2670.92

"Known" Stiffness Values

	A	B
Average	256.8	59.6
Minimum	207.6	40.4
Maximum	340.6	96.4
Std. Devation	41.6	17.9

		Unequal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00	17.70	84.96	3.20	271.87	11.80	1002.53
C2 (inches)	9.60	4.60	50.37	5.50	277.17	6.99	352.31
C3 (inches)	12.30	10.70	114.49	5.39	617.09	26.48	3032.08
C4 (inches)	9.10	12.20	82.35	3.51	289.16	41.99	3458.05
C5 (inches)	4.40	7.10	15.62	1.47	22.91	30.77	480.58
C6 (inches)	0.00						
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 6.65

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)
Minimum	207.6	40.4	12454.10	13318.06	10.3	11.0	23.9
Avg - 2 Std. Deviations	173.6	23.8	8678.34	10722.52	9.2	9.5	20.7
Avg - 1 Std. Deviations	215.2	41.7	12878.90	13793.92	10.5	11.2	24.3
Average	256.8	59.6	17079.46	17195.65	11.7	12.7	27.5
Avg + 1 Std. Deviations	298.4	77.5	21280.02	20698.82	12.8	14.0	30.4
Avg + 2 Std. Deviations	340.0	95.4	25480.58	24246.34	13.9	15.2	33.0
Maximum	340.6	96.4	25670.17	24368.75	13.9	15.3	33.1

Damage Centroid Depth (x) (inches)	4.25	k^2	3290.26
Damage Centroid Depth (y) (inches)	23.94	Eff. Mass Ratio (gamma)	1.00
Area of Damage (inches^2):	347.79		

1995 CADILLAC ELDORADO - Side Impact

Curb Weight (pounds):	3773
Occupant + Cargo Weight (pounds):	218
Total Weight (pounds):	3991
Angle Coll Force to Normal (degrees):	30.0
No Damage Speed (mph):	2.0
Energy Crush Depth (inches):	9.61
Damage Length (inches):	155.9
Crush Profile Measurements:	10

PDOF

Lever Arm Distance (inches):	28.50
Yaw Moment of Inertia (lb-ft-sec^2)	2904.73

		Unequal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00						
C2 (inches)	4.70	29.30	68.86	1.57	107.87	19.53	1344.97
C3 (inches)	9.60	18.30	130.85	3.71	486.08	28.50	3728.44
C4 (inches)	8.80	1.30	11.96	4.60	55.05	3.24	38.76
C5 (inches)	19.00	10.60	147.34	7.26	1069.96	37.75	5561.82
C6 (inches)	21.10	8.60	172.43	10.03	1730.19	38.78	6685.98
C7 (inches)	20.60	18.10	377.39	10.43	3934.43	99.51	37555.03
C8 (inches)	15.70	10.80	196.02	9.13	1789.69	69.96	13712.98
C9 (inches)	4.40	33.60	337.68	5.55	1875.61	248.85	84032.26
C10 (inches)	0.00	25.30	55.66	1.47	81.63	210.83	11734.98

Average Crush (inches): 9.61

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	bsub1
Minimum	30.4	11.2	12454.10	19666.11	12.2	10.4	13.0
Avg - 2 Std. Deviations	24.8	7.5	8678.34	14054.87	10.3	9.0	10.6
Avg - 1 Std. Deviations	31.0	11.7	12878.90	20295.29	12.4	10.5	13.3
Average	36.2	16.0	17079.46	26500.18	14.1	11.9	15.5
Avg + 1 Std. Deviations	40.9	20.3	21280.02	32682.01	15.7	13.2	17.5
Avg + 2 Std. Deviations	45.1	24.8	25480.58	38847.32	17.1	14.3	19.3
Maximum	45.3	25.0	25670.17	39125.26	17.1	14.4	19.4

Damage Centroid Depth (x) (inches)	7.43	k^2	3374.76
Damage Centroid Depth (y) (inches)	109.73	Eff. Mass Ratio (gamma)	0.81
Area of Damage (inches^2):	1498.18		

2006 CHEVROLET IMPALA MSP POLICE PACKAGE - Front Impact

Curb Weight (pounds):	3725
Occupant + Cargo Weight (pounds):	39
Total Weight (pounds):	3764
Angle Coll Force to Normal (degrees):	0.0
No Damage Speed (mph):	5.0
Energy Crush Depth (inches):	6.65
Damage Length (inches):	52.3
Crush Profile Measurements:	6

PDOF

Lever Arm Distance (inches):	0.00
Yaw Moment of Inertia (lb-ft-sec^2)	2670.92

"Known" Stiffness Values

	A	B
Average	256.8	59.6
Minimum	207.6	40.4
Maximum	340.6	96.4
Std. Devation	41.6	17.9

		Unequal Spacing (inches)	Zone Area (inches^2)	Zone Depth(x) (inches)	Area Depth(x) (inches^3)	Zone Depth(y) (inches)	Area Depth(y) (inches^3)
C1 (inches)	0.00						
C2 (inches)	9.60	17.70	84.96	3.20	271.87	11.80	1002.53
C3 (inches)	12.30	4.60	50.37	5.50	277.17	6.99	352.31
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C5 (inches)	4.40	12.20	82.35	3.51	289.16	41.99	3458.05
C6 (inches)	0.00	7.10	15.62	1.47	22.91	30.77	480.58
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							

Average Crush (inches): 6.65

Results

	A	B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)
Minimum	207.6	40.4	12454.10	13318.06	10.3	11.0	23.9
Avg - 2 Std. Deviations	173.6	23.8	8678.34	10722.52	9.2	9.5	20.7
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Maximum	340.6	96.4	25670.17	24368.75	13.9	15.3	33.1

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Area of Damage (inches^2):	347.79		

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Energy Crush Depth (inches):	9.61
Damage Length (inches):	155.9
Crush Profile Measurements:	10

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