INITIAL ASSESSMENT OF TARGET POPULATION FOR POTENTIAL REDUCTION OF PEDESTRIAN HEAD INJURY IN THE UNITED STATES:

An Estimate Based on PCDS Cases

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FEBRUARY 2004

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Brief Summary of Method

- PCDS cases were sorted according to impact surface
- Impact surfaces were categorized by their scope for improvement, i.e. whether they could be improved to potentially reduce risk to pedestrians
- The number of people in the PCDS database who sustained head injuries against "improvable" surfaces was tallied resulting in an estimate of the "Target Population." The Target Population included pedestrians whose most serious injuries included a head injury that could potentially be reduced with improvements to vehicle design.
- A head injury case is included in our Target Population if a pedestrian's most severe head injury from an impact surface that is considered "improvable" is *at least as severe* as the pedestrian's most severe intractable injury.
- The Target Population derived from the PCDS data was adjusted based on changes in the vehicle fleet since the period during which the PCDS data was collected.
- The Target Population estimate was applied to pedestrian injury statistics for 2002, resulting in an estimated annual number of pedestrian injuries and deaths that could potentially be reduced or prevented by improvement to the structures considered.

Summary of Source Data

The analysis was based on the 550[1] cases in the Pedestrian Crash Data Study [PCDS][2] database. Of these cases, 540 had at least one injury of known severity, and 242[3] had at least one head injury. A total of 761 head injuries are listed in the database. PCDS records the vehicle impact surface for each injury. Table 1 contains a summary of the frequency of head injury from impacts to various surfaces. A large number of these real-world head injuries are a result of impacts to surfaces that are included in the head test procedures that were proposed by the International Harmonization Research Activity (IHRA) Pedestrian Safety Working Group to the UN/ECE/WP29 GRSP pedestrian safety ad hoc group[4] in 2003.

[1] As per personal communication with Marv Stephens of NCSA, two duplicate cases were excluded from publicly available, 552-case version of database.
[2] Chidester A, Isenberg R. "Final Report on the Pedestrian Crash Data Study," Paper No. 248, ESV 2001.
[3] Head injury included all records coded as REGION90=1, therefore face injuries excluded.
[4] An informal working group within the Transport Division of the United Nations Economic Commission for Europe; WP29 is a world forum for the global harmonization of vehicle regulations

Table 1: Frequency of head injuries by impact surface

Contact Surface/Area	Number of injuries (N=761)	AIS 2-6 injuries (N=481)	AIS 3-6 injuries (N=393)
A-Pillar / Header	85	65	54
Front bumper/Valence	13	12	11
Environment (including ground)	134	61	45
Grille, headlamps, etc.	2	0	0
Hood surface	134	89	69
Areas adjacent to hood[5]	70	39	31
Non-contact	4	4	4
Side, roof, or rear component	22	12	9
Undercarriage	4	2	2
Windshield	293	197	168

Estimation of Target Population from PCDS

The Target Population among all PCDS cases was estimated. This population is the number of PCDS cases that included a head injury from hitting a vehicle component potentially covered by a proposed test procedure that was *at least as severe as* any other head injury, and *at least as severe* as any injury to any other body part. The Target Population, therefore, includes cases where the highest AIS head injury was sustained by striking a surface that could potentially be "improved" by appropriate countermeasures. The Target Population does not include pedestrian cases where the head injury was sustained in an impact not affected by any test procedures, such as with the ground or with the undercarriage of the vehicle. For example, the Target Population would include a pedestrian with an AIS 3 head injury from hood impact, only if the victim did not have any AIS 4-6 head injuries from impacts with the ground, etc. Furthermore, the Target Population would include a pedestrian with an AIS 3 head injury, only if the victim did not have any AIS 4-6 injuries to another body part. Although there is undoubtedly benefit to reducing this pedestrian's head injury severity, the pedestrian is not counted in the Target Population.

Since it is debatable which vehicle surfaces should be included in a test procedure, and which vehicle components could potentially be improved by design or material changes, the Target Population was estimated for a number of different scenarios. The first scenario assumes that only head injuries from impacts to the hood surface can potentially be mitigated. Each subsequent scenario is based on the assumption that additional vehicle components have scope for improvement, resulting in a larger Target Population.

[5] Including front edge of hood, upper surface of fender, cowl, etc.

Table 2: Definition of each set of vehicle components considered

Scenario	Specific vehicle components included (with corresponding PCDS Injury Source code)
1 – Hood surface	• Hood surface (770) • Hood surface reinforced by under hood component (771)
2 – All the above, plus surfaces adjacent to the hood	• Hood edge and/or trim (703) • Hood ornament (704,705) • Front antenna (721, 741) • Front fender top surface (772) • Cowl area (773) • Wiper blade & mountings (774)
3 – All the above, plus bumper/grille area	• Front bumper (700) • Front lower valence/spoiler (701) • Front grille (702) • Headlight (706) • Retractable headlight door (open/closed) (707) • Turn signal/parking lights (708) • Other front or add on object (718) • Unknown front object (719)
4- All the above, plus A-pillar and Header	• A1 pillar, right (722) • A1 pillar, left (742) • Front header (776)
5 – All the above, plus Windshield	• Windshield glazing (775)

Tables 3-1 to 3-5 list the number of PCDS cases that would be part of the "Target Population" under each scenario. These numbers are also listed as a percentage of the total population of injured pedestrians in PCDS. Results are tabulated for all injuries (AIS 1-6), for moderate injuries (AIS 2-6) and for serious injuries (AIS 3-6), separated by light trucks and vans (LTV) and passenger cars.

Table 3: Target Population in PCDS given various improvement scenarios (Head injuries that could potentially be reduced by vehicle improvement, as a percentage of the total number of injury cases)

(3-1) Scenario one assumes potential injury reduction from impacts to ***HOOD*** only

	LTV (n=170)	Pass Car (n=370)	Total (n=540)
All	11 (6.5%)	23 (6.2%)	34 (6.3 %)
AIS 2-6	10 (10.1%)	16 (7.9%)	26 (8.6%)
AIS 3-6	6 (9.0%)	6 (4.7%)	12 (6.2%)

(3-2) Scenario two assumes potential injury reduction from impacts to ***HOOD AND ADJACENT STRUCTURES:***

Head Injuries	LTV	Pass Car	Total
All	19 (11.2 %)	32 (8.6%)	51 (9.4 %)
AIS 2-6	18 (18.2%)	20 (9.9%)	38 (12.6%)
AIS 3-6	11 (16.4%)	9 (7.1%)	20 (10.3%)

(3-3) Scenario three assumes potential injury reduction from impacts to ***HOOD, ADJACENT STRUCTURES, BUMPER, and GRILLE AREAS:***

Head Injuries	LTV	Pass Car	Total
All	20 (11.8%)	34 (9.2%)	54 (10.0%)
AIS 2-6	18 (18.2%)	22 (10.8%)	40 (13.3%)
AIS 3-6	11 (16.4%)	11 (8.7%)	22 (11.3%)

(3-4) Scenario four assumes potential injury reduction from impacts to ***HOOD, ADJACENT STRUCTURES, BUMPER, GRILLE, A-PILLAR and HEADER AREAS:***

Head Injuries	LTV	Pass Car	Total
All	25 (14.7%)	53 (14.3%)	78 (14.4%)
AIS 2-6	23 (23.2%)	40 (19.7%)	63 (20.9%)
AIS 3-6	15 (22.4%)	24 (18.9%)	39 (20.1%)

(3-5) Scenario five assumes potential injury reduction from impacts to ***HOOD, ADJACENT STRUCTURES, BUMPER, GRILLE, A-PILLAR, HEADER AREAS and WINDSHIELD:***

Head Injuries	LTV	Pass Car	Total
All	35 (20.6%)	106 (28.6%)	141 (26.1%)
AIS 2-6	30 (30.3%)	85 (41.9%)	115 (38.1%)
AIS 3-6	22 (32.8%)	59 (46.5%)	81 (41.8%)

Adjustment of PCDS Target Population to Account for Changing Fleet

PCDS cases include crashes that occurred from 1994 to 1998 (mean 1996.4, median 1996). Vehicle models ranged from 1988 to 1999 (mean 1993.2 and median 1993).

During the period of data collection (1994 to 1998), LTV registrations as a percentage of total registrations increased steadily from approximately 32% to approximately 36%[6] for an average of approximately 34%. By 2001, LTV registrations comprised approximately 38% of the fleet. Sales of LTV's had reached almost 50% by 2001. Given the steady annual increase in registrations and sales of LTV's, an estimate of *current* LTV registrations is 40% and rising. It is reasonable, given sales trends, to predict that *future* LTV registrations will reach 50%.

[6] "Initiatives to Address Vehicle Compatibility", NHTSA report, June 2003, *www-nrd.nhtsa.dot.gov/departments/nrd-11/aggressivity/IPTVehicleCompatibilityReport/* . Percentages were estimated from bar-chart in this report.

For most scenarios, a higher percentage of the LTV cases in the PCDS database are in the Target Population (i.e. in more of the LTV cases, the most serious injury is a head injury that could potentially be reduced or prevented with vehicle improvements). Therefore, the increasing proportion of LTV's in the fleet will change the proportion of pedestrian head injuries that are potentially preventable. The estimates of the total Target Population in Tables 3.1 through 3.5 were adjusted to reflect the expected proportions of preventable injuries given changing LTV presence in the fleet. The resulting adjusted Target Populations are listed in Tables 4.1 through 4.5.

Table 4: Estimated Target Population - Percentage of injury cases where most serious injury is a head injury that could potentially be reduced or prevented (Given projected proportion of LTV's in vehicle fleet).

(4-1) Scenario one assumes potential injury reduction from impacts to ***HOOD*** only

Head Injuries	PCDS (34% LTV Fleet)	Projected Current (40% LTV Fleet)	Projected Future (50% LTV Fleet)
All	6.3%	6.3%	6.3%
AIS 2-6	8.6%	8.8%	9.0%
AIS 3-6	6.2%	6.4%	6.8%

(4-2) Scenario two assumes potential injury reduction from impacts to ***HOOD AND ADJACENT STRUCTURES:***

Head Injuries	PCDS (34% LTV Fleet)	Current (40% LTV Fleet)	Future (50% LTV Fleet)
All	9.4%	9.7%	9.9%
AIS 2-6	12.6%	13.2%	14.0%
AIS 3-6	10.3%	10.8%	11.8%

(4-3) Scenario three assumes potential injury reduction from impacts to ***HOOD, ADJACENT STRUCTURES, BUMPER, and GRILLE AREAS:***

Head Injuries	PCDS (34% LTV Fleet)	Current (40% LTV Fleet)	Future (50% LTV Fleet)
All	10.0%	10.2%	10.5%
AIS 2-6	13.2%	13.8%	14.5%
AIS 3-6	11.3%	11.8%	12.5%

(4-4) Scenario four assumes potential injury reduction from impacts to ***HOOD, ADJACENT STRUCTURES, BUMPER, GRILLE, A-PILLAR and HEADER AREAS:***

Head Injuries	PCDS (34% LTV Fleet)	Current (40% LTV Fleet)	Future (50% LTV Fleet)
All	14.4%	14.5%	14.5%
AIS 2-6	20.9%	21.1%	21.5%
AIS 3-6	20.1%	20.3%	20.6%

(4-5) Scenario five assumes potential injury reduction from impacts to ***HOOD, ADJACENT STRUCTURES, BUMPER, GRILLE, A-PILLAR, HEADER AREAS and WINDSHIELD:***

Head Injuries	PCDS (34% LTV Fleet)	Current (40% LTV Fleet)	Future (50% LTV Fleet)
All	26.1%	25.4%	24.6%
AIS 2-6	38.1%	37.2%	36.1%
AIS 3-6	41.8%	41.0%	39.6%

The percentages in the above tables represent the percent of injured pedestrians whose most serious injuries are head injuries that could potentially be mitigated. In summary, given the current proportion of LTV's in the US fleet (approximately 40%), the Target Population for head injury reduction as a result of vehicle improvements for pedestrian safety would be between 6.3% (Table 4-1, All Head Injuries) and 25.4% (Table 4-5, All Head Injuries) of all injured pedestrians, depending on the range of vehicle improvements assumed possible. Considering only moderate and worse injuries (AIS 2-6), the Target Population would range from approximately 9% (Table 4-1, AIS 2-6) to 37% (Table 4-5, AIS 2-6) of all injured pedestrians for the current vehicle fleet. This projected Target Population is not dramatically different than the Target Populations calculated based on earlier fleets with fewer LTV's or projected from a future fleet with more LTV's.

Application of Target Population Estimate To Annual Number of Pedestrians Injured

The number of pedestrians in the Target Population was estimated based on National Center for Statistics and Analysis (NCSA) data for 2002,[7] which listed 4,808 pedestrian fatalities and 71,000 pedestrians injured.

Assuming that LTV's comprised approximately 40% of the fleet in 2002, the projected *current* Target Population percentages from Tables 4-1 through 4-5 were applied to NCSA's 2002 injury statistics to estimate how many of the injured pedestrians could potentially have benefited from improved vehicle structures. In Table 5, the Target Population percentages calculated from all severities of injury from the PCDS database (AIS 1-6) were used to estimate the Target Population among all injured pedestrians in 2002, while the Target Population calculated from the serious PCDS injuries (AIS 3-6) were used to estimate the Target Population among the killed pedestrians.

For example, under Scenario 1 in Table 4-1, it was estimated that 6.3 % of pedestrian injuries (AIS1-6) would be within the Target Population given the current fleet of 40% LTV's. That is, 6.3 % of injured pedestrians sustained a head injury from hood contact that was at least as serious as any other injury sustained. This estimate was applied in Table 5 by multiplying the estimated number of pedestrians injured (71,000) by 6.3%, to estimate a Target Population of 4,473 pedestrians with head injuries due to hood contact in 2002.

[7] "Traffic Safety Facts 2002, Pedestrians", NCSA, NHTSA, DOT HS 809 614.

Table 5: Target Population calculated by applying Target Population percentages from PCDS analysis to NCSA injury statistics from 2002.

	Pedestrians Injured	Pedestrian Fatalities
NCSA Statistics 2002	71,000	4,808
Target Population in 2002: *Based on projected fleet estimate of 40% LTV*	*Based on Target Population calculated from all PCDS injuries (AIS 1-6)*	*Based on Target Population calculated from serious PCDS injuries (AIS3-6)*
Scenario 1	4,473	308
Scenario 2	6,887	519
Scenario 3	7,242	567
Scenario 4	10,295	976
Scenario 5	18,034	1,971

This analysis shows the potential number of pedestrians that could be affected annually by improvements in vehicle structure. The magnitude of this Target Population depends on which vehicle components could potentially be improved by design or material changes. By the most conservative evaluation, assuming that only head injuries from direct impact to the hood can be mitigated, the Target Population is estimated to be 4,473 pedestrians, including 308 fatalities. Assuming that a test procedure could, in fact, result in improvements to a very wide variety of vehicle components, the benefits could potentially affect as many as 18,034 pedestrian head injuries including 1,971 fatalities.

Limitations of Method

This estimate of Target Population was intended as a "back-of-the-envelope" estimate. It is limited by the following assumptions and shortcuts:

- It is assumed that the PCDS cases are representative of the population of pedestrian injuries. In particular, it is assumed that the percentage of head impacts to "improvable" surfaces in all injury cases is the same as that in the US population, and that the percentage of impacts to "improvable" surfaces in the AIS 3-6 head injury cases are the same as in US pedestrian fatalities.
- Given the year range of the vehicles in the PCDS database, and the change in vehicle profiles since that time, it is likely that today's fleet has different percentages. Although this is partly accounted for by adjusting for SUV and Light truck fleet increases, even the shape of LTV's and SUV's have changed since that time.
- Although head injured pedestrians obviously benefit from head injury reduction even if they injure other body parts more seriously, this benefit is neglected in this Target Population analysis.
- It is customary in benefit calculations to only count 50% of an injury benefit if there is another "unsavable" injury of the same AIS level. Although this analysis does not count injury benefit if there is another injury of higher AIS level, this analysis did not account for cases where there was an injury of the same AIS level. That omission likely means the final estimate is probably more liberal than it would be if done in the customary way.