NCAP - FIELD RELEVANCE OF THE METRICS

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ABSTRACT

By design, frontal New Car Assessment Program (NCAP) tests focus on a narrow portion of the spectrum of field crash events. A simple, high level parsing of towaway crashes from NHTSA's National Automotive Sampling System - Crashworthiness Data System (NASS-CDS) files shows that only a small fraction of occupants (but a somewhat larger portion of their harm as measured by ISS) find themselves in crash circumstances remotely similar to NCAP crash conditions. Looking only at seat location, area of damage, direction of force, distribution of damage, and estimated delta-V filters significantly restricts the relevance of NCAP even before critical factors like belt use and vehicle crash partner are considered.

Given the limited scope of frontal NCAP it should not be surprising that it has limited usefulness in discriminating among various vehicles' overall performance in the field.

INTRODUCTION

NCAP has been in existence for over 20 years, as a major consumer information program of the National Highway Traffic Safety Administration (NHTSA). There are two major crash performance test components of NCAP -- the original, frontal, distributed, rigid, fixed barrier test, and the more recently introduced, side, deformable, moving barrier test. The test configurations are similar to compliance tests specified in FMVSS-208 and FMVSS-214, but run at higher speeds.

A question arises as to how relevant these NCAP crash tests are to field crashes. That question can be answered a number of different ways depending on how the target population is defined and what measures are used to gauge relevance.

To illustrate one approach to the answering the question, this paper examines the field relevance of the frontal NCAP test using NHTSA's NASS-CDS data sets for the years 1995-1999. NASS-CDS covers crashes involving light vehicles that were towed from the scene due to damage. NASS-CDS's case selection criteria represent a an attempt at balancing the competing goals of capturing all injuries or examining only crashes with a high risk of occupants being injured due to crash forces. So for the purpose of this paper, the "universe" will consist of occupants of light vehicles in towaway crashes as sampled by NASS-CDS.

Relevance of tests to this field crash universe can be judged by many standards but at a minimum the frequency of occupants exposed to similar crash conditions is one measure of relevance. Another dimension that should be considered is a measure of harm to people due to the injuries that they suffer. This second dimension has many possible candidate metrics. For the purpose of this paper, Injury Severity Score, ISS, is the measure chosen to factor harm into consideration. ISS was selected as the measure of harm because it correlates with the probability of fatality, the length of hospital stay, and other measures of morbidity.

Starting with the "universe" of vehicle occupants in towaway crashes, we can explore the relevance of frontal NCAP tests by narrowing the scope of crashes to those that are somewhat similar to the specified test condition. At each step in the filtering process one can judge the impact of each filter and the cumulative effect of all the preceding filters on the two measures of relevance (frequency and ISS).

There are a variety of ways of grouping relevant vehicle and crash variables to create a reasonable representation of NCAP test conditions. Rather than carrying the examination to extremes, this paper studies the effect of four classes of vehicle and crash variables:

Occupant Seating Location
General Vehicle Damage
Horizontal Damage Location/Impact Direction,
Delta-V of the Crash.

Occupant Seating Location

Frontal NCAP measures the response of dummies in the front outboard seating positions (i.e. driver and right front passenger). Figure 1 shows that these two positions account for 86.3% of all occupants and 91.6% of their ISS. From a priority standpoint, drivers and then right front passengers are the logical groups to study.

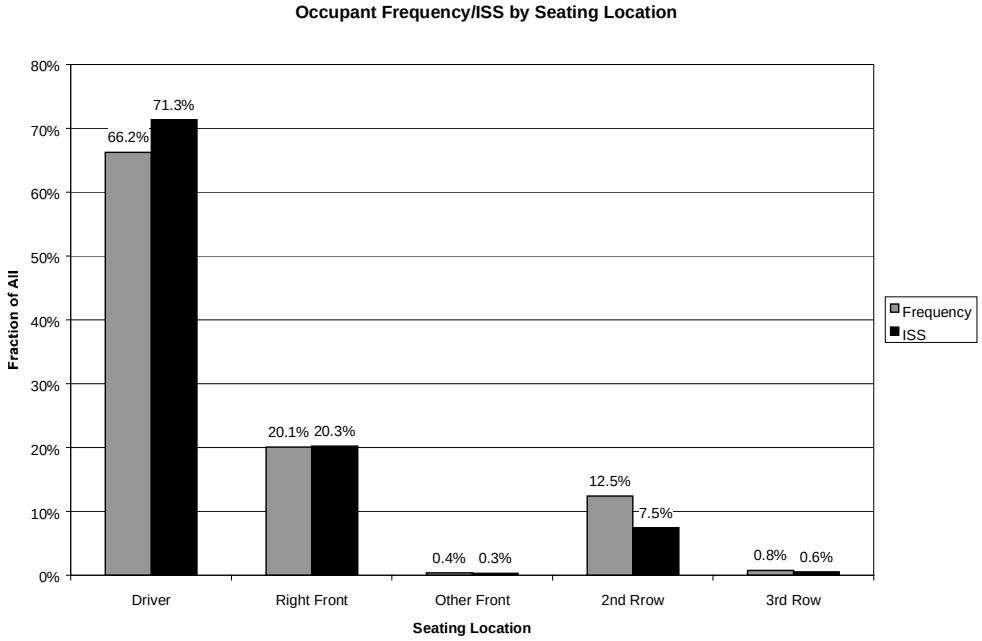

Figure 1: Occupant Frequency/ISS Distribution by Seating Location

General Vehicle Damage

The next step examines the types of crashes these front outboard occupants experience. Crashed vehicles involving rollover are put in one category, while the remaining vehicles are categorized by their vehicle's primary Collision Damage Classification general area of damage code. Figure 2 shows that 49.4% of occupants and 42.5% of light vehicle ISS is accounted for by front outboard occupants in the broadly defined non-rollover frontal crash category.

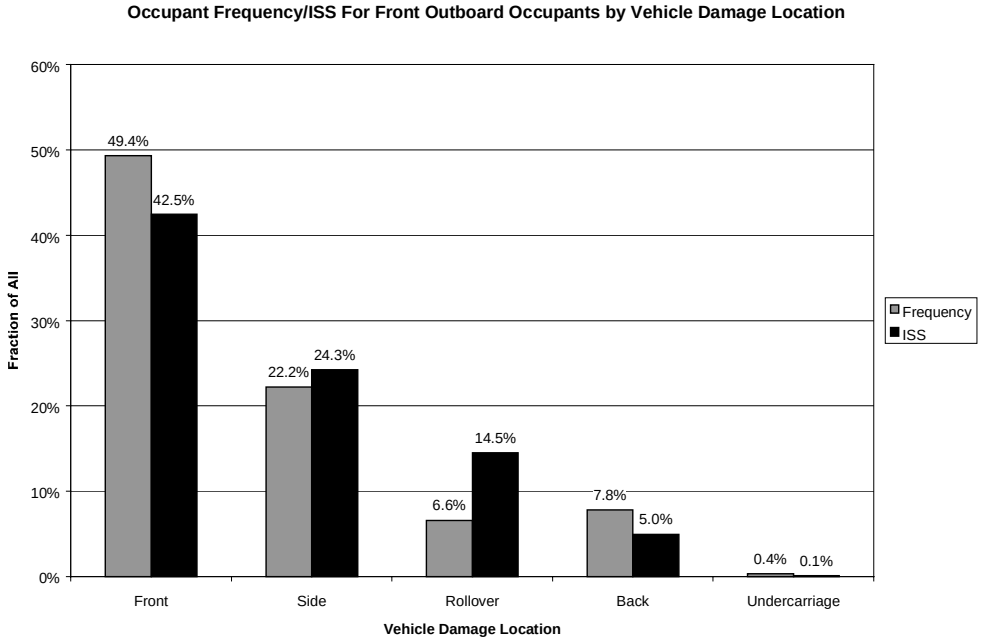

Figure 2: Front Outboard Occupant Frequency/ISS Distribution by Vehicle Damage Category

The frontal crash category accounts for the largest number of exposed front outboard occupants and the largest contribution to their harm as measured by ISS. It is reasonable to select frontal crashes as the most relevant to field crashes in general, even though, on a per crash basis, side impacts and rollover have a larger influence on harm as measured by ISS.

Horizontal Damage Location/Impact Direction

The previous step defined frontal crashes very broadly to include non-rollover crashes with primary damage to the front of the vehicle. This step looks a little closer to see what fraction of the broadly defined frontals have horizontally distributed damage, with the impact coming from the 12 o'clock direction.

Based on the primary CDC coding, the frontal category is split according to whether the damage is "12FD" or not. Figure 3 shows that only 12.5% of the occupant frequency and 11.4% of their harm as measured by ISS fall in the category of front outboard occupants in "12FD" non-rollover impacts.

Viewed this way, the suggestion is that 12 o'clock distributed frontals are less field relevant than other frontals. But no other combination of clock direction and horizontal damage area approach the field relevance of the "12FD" combination. Also note that the "Yes" group makes a larger relative contribution to harm, on a per crash basis, than the remaining frontals. So it is reasonable to choose the "12FD" configuration over any other particular frontal direction/area combination.

Even so, the specification of "12FD" impacts covers a lot of territory. The direction of impact can vary by plus or minus 15 degrees, the entire width of the vehicle doesn't have to be engaged to qualify as a distributed impact, and nothing is implied about the vertical distribution of damage nor the object contacted. The choice of object contacted can be expected to have a significant effect on the abruptness of a vehicle's crash deceleration. Other than arbitrarily assigning objects to stiff or soft categories, little can be said from the existing NASS-CDS files about this crash factor. Future generations of NASS-CDS will undoubtedly incorporate information from on-board crash recorders to accurately address this question, but there is little doubt that only a small fraction of crashes approach the abruptness of a rigid barrier impact.

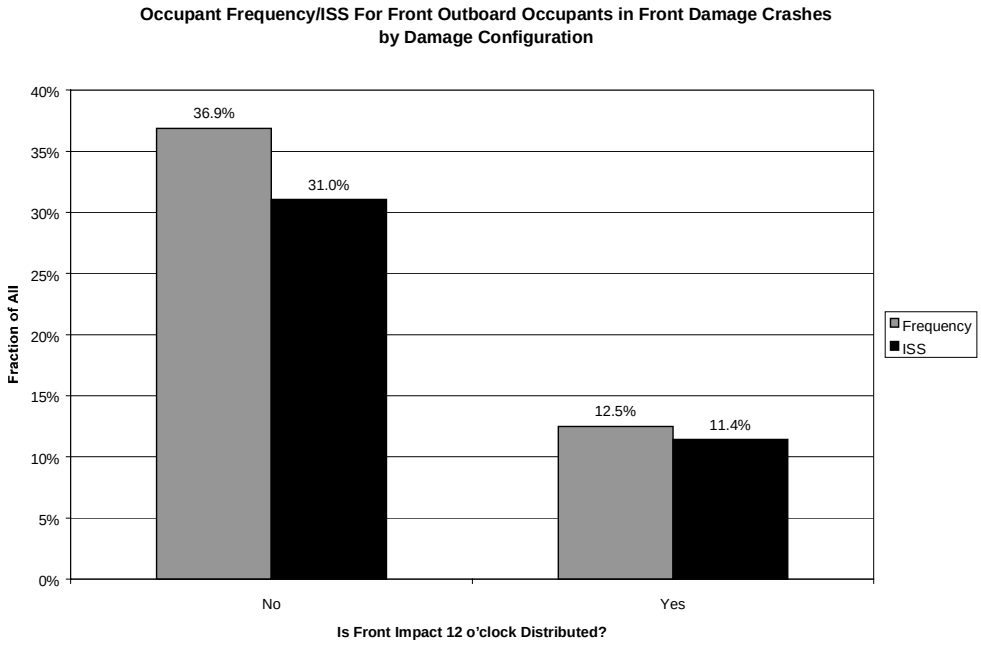

Figure 3: Front Outboard Occupant Frequency/ISS Distribution by Vehicle Direction/Damage Category

Vehicle Change in Velocity (Delta-V)

Just as for the shapes of the crash deceleration pulse, future generations of NASS-CDS will provide improved estimates of total crash-induced change in vehicle velocity or delta-V for individual crashes, but the current crash tools give a reasonable understanding of this parameter in the aggregate. Figure 4 shows the distribution of front outboard occupants and their ISS by delta-V (rounded to the closest 5 km/h) in all non-rollover front damage crashes (not just "12FD" crashes).

In terms of exposed occupants, the 15 km/h category represents the mode at 16.8%. For harm, as measured by ISS, the 20 km/h category has the highest frequency at 8.9%. Frontal NCAP's 35 mph (56 km/h) would fall in the 55 km/h category which accounts for only 0.2% of frequency and 1.3% of the harm. These small fractions have not been reduced by screening the data by the previously discussed factors of direction of impact, horizontal area of damage or object contacted, or by other factors such as belt use or occupant size.

Even so, it is clear that the frontal NCAP test conditions represent a much more severe condition than the field crashes which produce the most occupant harm.

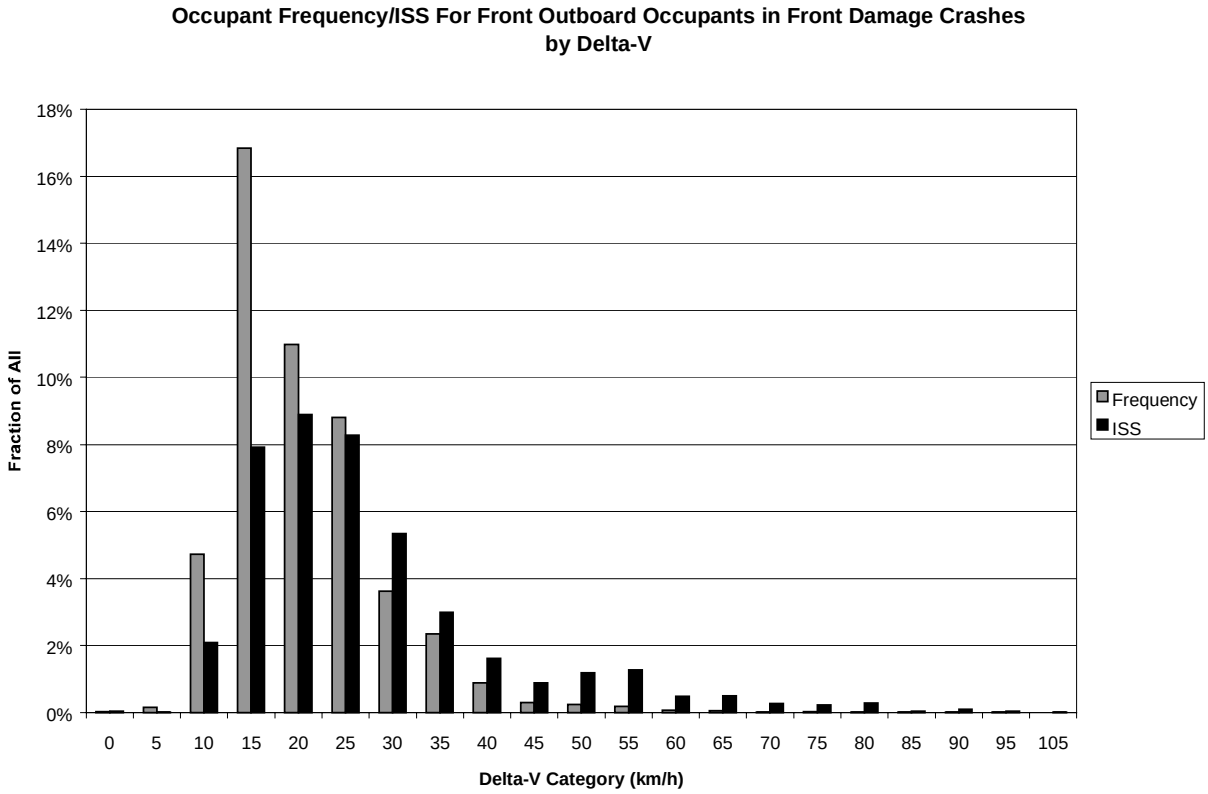

Figure 4: Front Outboard Occupant Frequency/ISS Distribution by Vehicle Delta-V in Frontal Crashes

CONCLUSION

Whereas certain published research (e.g. Kahane, 1994) has found NCAP to be a good indicator of crash performance in portions of the field crash spectrum, other papers (e.g. Libertiny 1995) have found NCAP a less than ideal predictor of field crash performance. Both of these perspectives are valid if properly qualified.

For most of the factors considered, the frontal NCAP conditions make sense in terms of being relevant to relatively large fractions of occupant frequency and harm. It is in the matter of crash severity that frontal NCAP is less relevant to the range of crashes that people actually experience in the field or that cause the most harm. It might be appropriate to consider such extreme test to force improvements in crashes occurring in the tail of the severity distribution, but it is another matter to suggest that these results are relevant to the vast majority of crash outcomes.

Data from on-board crash recorders will augment the already outstanding resource that NASS-CDS represents. These data will allow future researchers to better relate field and laboratory testing. They will facilitate quantitative determinations of the field relevance of different testing protocols.

Carried to the extreme, the search for the fraction of field events identical to any one given test will result in the answer that none match in all details. All one can hope for in one test is that it is reasonably representative of conditions which are likely to occur (supposedly the objective of the current frontal NCAP test protocol). But it still represents only one set of conditions. This paper's simple approach to parsing just a few of the factors shows that it doesn't take many cuts of the data to isolate a reasonable test from the vast majority of field events.

REFERENCES

Baker, S. P. et al, "The Injury Severity Score: a method for describing patients with multiple injuries and evaluating emergency care", J Trauma 14:187-196; 1974

Kahane, C. J. Correlation of NCAP Performance with Fatality Risk in Actual Head-on Crashes, NHTSA Technical Report DOT HS 808 061, Washington D.C.: NHTSA, January, 1994.

Libertiny, G.Z. An Assessment of the Reliability of the NHTSA New Car Assessment Program, SAE Technical Paper SAE-950825, Ford Motor Company, Presented at the SAE International Congress and Exposition, Detroit, MI, February 27-March 2, 1995.

National Automotive Sampling System (NASS) Crashworthiness Data System, Analytical User's Manual, 1997 File, Washington D.C.: NHTSA, National Center for Statistics and Analysis, 1997