Table 2: Limitations of Computer Simulations of Appurtenance Collisions

Areas of Simulation Difficulty	Causes of Difficulty
6. Impact with sign posts, liminarie supports	Vehicle wrap-around locally--snagging; details of post-vehicle interface geometry Localized deformation property of vehicle Post-soil interaction Breakaway supports--limiting dynamic strength of supports
7. Crash cushion impact	3-D effects--ramping or nosing--relative interface geometry and c.g. heights of vehicle and cushion; curbs Characterization of cushion module deformation properties--stiffness, rate effects, fracture, mass loss
8. Articulated vehicles	Constraint conditions at fifth wheel--slack, stiffness
9. High center of gravity vehicles	Rollover resistance--suspension tension properties, slack; suspension compressive bottoming properties
10. Vehicle deformation properties	Function of position on exterior envelope
11. Simulation output	Vehicle accelerations--not as accurate as kinematics--correlation with occupant risk

LIMITATIONS ASSOCIATED WITH ANTHROPOMETRIC DUMMIES

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Due to current anthropometric dummy technology limitations, dummy response data from crash tests do not provide a sufficient linkage with roadside feature collision severity. As shown in Table 3, limitations can be categorized into three areas: surrogate representativeness, surrogate response interpretation and relationship between surrogate response and performance of roadside feature.

With regard to representativeness, current dummies were developed for vehicle restraint evaluations in which the vehicle experiences a highly directional and abrupt velocity change such as a head-on collision into a rigid barrier. Their use in evaluating roadside features in which the collision may be prolonged over several hundred millisecond duration, where there may be multiple vehicle impacts, where the vehicle may be redirected and where the dummy may be unrestrained is certainly questionable. Of particular concern is the current dummy biofidelity for crashes in which large side forces are introduced, such as a typical longitudinal guardrail redirectional test.

Table 3: Limitations Associated with the Use of Anthropometric Dummies to Evaluate Roadside Countermeasures

Limitations	Issues of Concern
Surrogate representativeness	Biofidelity--general indication of collision severity seen by occupant, not intended for highly specific lesion prediction/assessment Kinematics Occupant population Current 50th percentile dummies Hybrid II (Part 572)--restraints development and vehicle safety evaluations, FMVSS testing, thought undesirable for side restraint development Hybrid III--improved chest and neck characteristics, thought undesirable for side restraint development; dummies for side impacts--being evaluated, injury measures undecided, matching responses from dummies to injuries in real-world accidents

Table 3: Limitations Associated with the Use of Anthropometric Dummies to Evaluate Roadside Countermeasures

Limitations	Issues of Concern
Surrogate response interpretation	NHTSA pass/fail criteria Head injury criteria ≤1000 Chest acceleration ≤60 g Femur loads ≤2250 lb. Other injury measures proposed Repeated tests for statistical validity More research needed on relationship of dummy injury measures to human injury level probabilities Methodology for deriving relationships has been developed and implemented; work needs to be continued Current relationships interpret measures as indicators of overall injury probability
Relationships between surrogate response and performance of a roadside feature	What the response is measuring Roadside countermeasure and restraint-structure system performance combined Performance relative to "expected" vehicles Free flight distance/padding effects, etc. Repeatability--variations due to nature, positioning, instrumentation Problems in assessment in accordance with the Report 230 procedure--time of contact - different for various body regions, differences between driver and passenger Increased testing costs

Interpretation of dummy response is a second issue of concern. The FMVSS 208 criteria are a fail/pass standard directed specifically to restraint system development. The question concerning the suitability of using these criteria for evaluating roadside hardware is: Are they appropriate and suitable severity indicators? The FMVSS 208 criteria are being questioned as to their relationship to real-world collision results even in the most restrictive use; what does a Head Injury Criteria (HIC) of 1000 mean, and how does it relate to the probability and degree of occupant injury?

And third, the relationship between surrogate response and performance of a specific roadside feature is at present most tenuous. Given the variability of the vehicle occupant flail space and interior geometry and padding, sensitivity of positioning of dummies, increased costs associated with testing with dummies, etc., it is evident that considerable research is needed before the dummy can provide the linkage between crash test results and highway accident statistics. Specifically, research should be implemented to conduct further work on refining relationships between dummy injury measures and injury probabilities and to examine what the sources of variability in injury measures and injury levels for given crash severities and impact conditions are and their relative contributions to overall variability.

RELATIONSHIP OF CRASH PARAMETERS AND ACCIDENT INJURIES

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In order to compete in the marketplace in the 1980s, automobile manufacturers are rapidly moving toward more sophisticated designs and design techniques that shall provide smaller, lighter in weight and energy-efficient vehicles. The smaller front-wheel-drive vehicles, diesel engines, material substitution and advanced computer technology will play significant roles in the future of this industry. Predictions by NHTSA and others indicate that the small car will comprise the majority of automobiles in the vehicle fleet by the mid-1980s. In addition, projections have been made indicating an increasing number of fatalities with nearly one million fatalities and tens of millions of serious injuries to occur in automobiles during the next 20 years. The goal of the safety community should be to reduce these numbers by as much as possible.

To reach this goal of reduced injuries and fatalities requires knowledge of the relative crash characteristics of automobile designs. A coordinated effort to establish a standardized computer data base from which this knowledge can be extracted should be pursued. The NHTSA has developed and is maintaining such a data base. Currently, this data base contains almost 400 crash tests of recent model vehicles. In addition, an effort to determine the relationship between crash tests and real-world accident experiences should be better defined. Again, NHTSA is pursuing this activity. In June 1981, at the SAE Conference in Detroit, Mr. Hackney discussed a methodology for determining the relationship of crash parameters and injury measures such as that between the Head Injury Criteria (HIC) and Chest Severity Index (CSI) and the Abbreviated Injury Scale (AIS). These relationships, shown in Figures 1 and 2, were further explored by Hackney to determine the probabilities of serious injuries and fatalities. Comparisons were made to relationships obtained from the accident data files (using the change in velocity as the common denominator) and are summarized in Figure 3. It must be emphasized that these results are preliminary and further refinements are in progress.