ISSUE: WHAT METHODS CAN BE USED TO ACQUIRE OR DEVELOP IN-SERVICE COLLISION PERFORMANCE DATA OF ROADSIDE APPURTENANCES?

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After considerable discussion of the type of collision data that should be of primary concern to this undertaking, a conclusion was reached that purely statistical performance and analysis data were not what was wanted. Rather, data of a clinical nature such as of vehicle impacts, appurtenance performance, highway environment and specific collision performance information associated with each type of safety device would be relevant. Depending on the appurtenance system being considered, the desired pertinent data may possibly lie somewhere between clinical and statistical in nature. This would include descriptive information such as size and weight of impacting vehicles, number of collisions, angle of impact, resultant damage and personal injury and system performance.

The group next discussed who should do it by considering the pros and cons of four distinct resource bases: insurance companies, transportation agencies (state, county, municipal, police), public entity and private sector and NASS system (PSU's). After much deliberation, it was felt that the transportation agencies were the most qualified and better-suited groups to perform the data acquisitioning for collision performance of safety devices on our transportation network. Only new systems should be included in this endeavor because of the urgency for the required greater performance of smaller and lighter-weight automobiles. Further discussion emphasized the many complexities associated with evaluating existing installations in this program. When detailed clinical data would be required, the PSU's or private accident investigators could be employed.

The planned program for the collection of collision performance data should be capable of short-term as well as long-term continuance activity. The developed program must be implemented with conditions of the real world in mind, i.e., considering actual field conditions. There should be a trial period for experimental design. Failures and successes of systems under evaluation should be recorded.

Because of personal decisions, subjectivity and appurtenance performances, two types of studies must be contemplated: system performance having recorded accident reports and system performance without accident reports.

Optimum use of photographic recording and on-site visual reports should be considered to supplement written accident report data by police, eyewitnesses, etc. In some cases, remote sensing, TV camera systems, etc., could be most worthwhile for the purpose. For on-site visual reporting, there must be involved personnel who have the best experience background with the technology associated with the contemplated system in order to determine actual collision performance. Employment of maintenance organization personnel could be rather effective and productive for performing this task. With experience and training, subjectivity in evaluations could be greatly reduced. Proper use might also be made of some degree of accident reconstruction, noting the attitude of the vehicle on contact with the appurtenance as well as information detailing the dynamics of the vehicle and kinematics of vehicle occupants.

ISSUE: THE LINK BETWEEN CONTROLLED VEHICLE CRASH TESTS AND LIKELIHOOD AND EXTENT OF OCCUPANT INJURY IN A SIMILAR REAL-WORLD COLLISION

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The following statements summarize the group's consensus:

1. Over the past 20 years or more, a great number of controlled crash tests have been conducted involving a fairly broad range of vehicles and a wide variety of highway safety appurtenances. Test variables have included impact velocity, impact angle, point of impact on the vehicle and/or the appurtenance, terrain conditions, etc. Data acquisition systems of varying capability have been employed to document the dynamic and the kinematic responses of the crash vehicle and the appurtenance. In most of the tests, the crash vehicle has contained one or more dummy occupants. In all of these crash tests, the pretest and posttest conditions were thoroughly documented by still photography. In most of the tests, the entire crash event, including dummy movements, were documented on high-speed film. Also, the responses of accelerometers mounted in the occupant compartment of the vehicle, and sometimes in the dummies themselves, were often recorded throughout the crash event.

2. In summary, crash test researchers know what will happen to the vehicle (acceleration, momentum change, velocity, trajectory, damage, etc.) during collision with a wide variety of highway safety appurtenances or can acquire such data through further crash testing when required.

3. Computer simulation programs are a valuable supplemental source for data on crash vehicle dynamics and kinematics during interactions with various highway appurtenances and/or terrain conditions provided they have been validated with the data from a sufficient number of crash tests, particularly tests that "bracket" the area of concern.

4. Crash test researchers have developed and/or used various "ballpark" criteria to estimate the likelihood of serious injury or fatality (a life-threatening situation) occurring in a specific vehicle/appurtenance crash test. These criteria have been based on the dynamic and kinematic data acquired from a controlled crash test, i.e., vehicle damage (body crush, occupant compartment integrity, etc.); vehicle kinematics (rollover, rebound, etc.); vehicle and/or dummy acceleration responses; degree of occupant restraint (unrestrained, lap belt, shoulder harness, etc.); dummy damage and movement; etc. These criteria have generally been developed from research performed by other than the normal highway research community and financed by NASA, NHTSA, etc. At best, these criteria have produced conservative estimates or predictions on the likelihood of serious injury or fatality occurring in a specific vehicle/appurtenance crash test. These criteria have not been capable of producing occupancy injury/fatality

estimates in the more detailed and exact terms (the probability of property damage, injury or fatality) needed to compare appurtenance or safety improvement alternatives on a cost/benefit basis.

5. The relationship between occupant safety and vehicle dynamics during interaction with a highway appurtenance is very tenuous because it involves to many widely varying factors such as occupant physiology, size, seating position, attitude and restraint and vehicle interior geometry and padding. For this reason, it appears that a "general" tie could best be developed between vehicle compartment acceleration and the probability of occupant injury. This tie should probably be based on unrestrained occupants unless the use of restraint systems becomes mandatory in the future. The development of such a tie would enable researchers to go back to make new injury severity judgments for past vehicle/ appurtenance crash tests where good acceleration data were documented.

6. It is reasonable for the minimum acceptable occupant injury levels to vary, dependent on the type of highway safety appurtenance involved. This is on the basis that the "art of the possible" enables lower impact resistances to be achieved, for example, with small highway signs compared with crash cushions.

7. Efforts are underway by others, such as under NHTSA sponsorship, to develop an improved instrumented anthropomorphic dummy that would be more capable of simulating human movements and recording human injury indicators in the occupant compartment during a vehicle/appurtenance crash test. The development of an improved dummy would enable researchers to make more detailed and accurate injury severity predictions. The dummies currently used in vehicle/appurtenance crash tests do not provide this capability.

8. Efforts have been made in the past by researchers such as Michalski in Oregon and Olson in Texas to relate the dagree of injury sustained in an accident to the vehicle damage. Although considerable additional work would be necessary, it may be possible to relate the observed type and magnitude of vehicle damage to occupant compartment accelerations, which in turn could be related to occupant-injury severity.

9. A better tie between crash test data and "real-world" accident injury severity could also be developed by reconstructing actual accidents where vehicle/appurtenance variables such as occupant restraint, vehicle damage, impact speed, impact angle, etc., and the actual level of injury are known. Known accidents could be reconstructed in controlled crash tests and simulated in computer programs. Through this process, the relationship could be developed between the data currently acquired in a vehicle/appurtenance crash test and the severity of injury that occurs in real-world accidents where the parameters are similar to vehicle/ appurtenance crash tests already performed. This would reduce the cost of such an effort.

ISSUE: UTILIZATION OF SIMULATION TO PREDICT LIKELIHOOD OF INJURY

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The discussions first centered about the role simulation has in the benefit evaluation for a proposed countermeasure to be introduced to the highway roadside. In considering all the parameters associated with the accident environment, it was concluded that crash testing alone provided limited data for a full benefit evaluation, and therefore simulation could fill the data needs provided that a meaningful analysis could be accomplished. The essential ingredients of a meaningful analysis included: an accurate depiction of the accident environment, an accurate (qualitatively and more desirably quantitatively) vehicle-roadside object simulation, an accurate occupant model and an accurate injury predictor model (based on deterministic occupant responses). The discussion then was directed toward each of the simulations.

The vehicle-roadside object simulations were first discussed. In particular, the status of the GUARD, CRUNCH, BARRIER VII and HVOSM models was presented with a particular emphasis placed on the data needs of the models for simulating the accident environment. Such data as soil-post interactions were mentioned to be lacking. A special concern expressed was the validation of simulation output compared with crash test results and/or accident reconstructions. Also, the changing fleet of automobiles presents a benefit evaluation problem in that an accurate projection of fleet distribution and characteristics are required for the evaluation effort.

The occupant models were discussed. It was generally agreed that, for the accidents simulated, a three-dimensional occupant simulator was required. In particular, the Calspan 3-D Crash Victim Simulator (CVS) was discussed. The particular data needs for this model included accurate data for modeling various size occupants, accurate geometry of the compartment interior, accurate energy absorbing characteristics of the vehicle interior components, accurate crash pulses from the vehicle-roadside object simulations, accurate models of the restraint systems, etc. Of prime importance was the need to make the CVS model user friendly. In that detailed data sets are required for the model, it was determined that efficient handling of data sets would lead to fewer man-hours required by the engineer to construct the model for the analysis.

The discussion next centered on the prediction of injury and hence leading to the prediction of the likelihood (or probability) of injury as related to physical information. First, the transformation of results processed from crash test data to injuries observed in the accident environment is required. Second, responses calculated from occupant models are generally different from those obtained from crash testing. Hence, a transformation from occupant simulation is required to close the loop compared with the injuries observed in the accident environment. Ongoing research being conducted by Chi Associates (probability of injury) and the University of Virginia /Safety Systems Optimization Model (SSOM)/ was discussed as to how these goals are being approached.

The concluding discussion then centered on performing the benefit evaluation once the models are in place. Again, the SSOM was discussed as to how that model approaches the evaluation. In addition, the Benefits Prediction Model (BPM) was discussed.