Report of the Second Public Meeting of the Blue Ribbon Panel for Evaluation of Advanced Airbags

The Blue Ribbon Panel (BRP) for Evaluation of Advanced Airbags held its second public meeting at the Ronald Reagan Building and International Trade Center in Washington, D.C., on April 14, 2004. The following is a brief summary of the individual presentations and an overall summary of the day's activities as summarized by the BRP Chairperson, Dr. Susan Ferguson, at the conclusion of the meeting. The complete presentations can be downloaded from the BRP website: http://brp.iihs.org

After welcoming all, Dr. Ferguson reviewed the BRP, its composition, major decisions to date, and the status of data collection and analysis. The Alliance of Automobile Manufacturers (Alliance) has committed to funding a 3-year, $4.5m program of crash data collection to be managed by an independent third party. Oversight is provided by a panel of experts consisting of representatives from the highway safety research community, the National Transportation Safety Board, academia, medical institutions, and the insurance industry. The Blue Ribbon Panel for Evaluation of Advanced Airbags, which met for the first time in February 2001, also includes representatives from NHTSA and the automobile industry who participate as observers.

At the first meeting, the BRP agreed that the goals are to answer three basic questions:

1) Are vehicles equipped with redesigned and advanced airbag systems as effective as vehicles equipped with first-generation airbags at reducing overall injury and death in frontal crashes?

2) Are vehicles equipped with sled-certified airbag systems offering reduced protection in higher-severity crashes, particularly for unbelted occupants?

3) Is the incidence of airbag-induced injuries to children and other vulnerable occupants lower in vehicles with redesigned airbags, particularly in low-speed frontal impacts?

After studying eight possible approaches for data collection, the BRP decided to use the existing NASS/CDS infrastructure to add three new data collection teams. The panel agreed that the Alliance-funded study should gather a probability-based sample of frontal crashes of all severity levels involving vehicles of the current model year and the four prior model years. The study should oversample higher-severity crashes. Data from this study will be incorporated with existing NASS data and can be weighted to estimate national crash rates. The crash data collected will be fully compatible with current NASS/CDS cases, thus enhancing the ability to use the total file for statistical analysis. The BRP agreed that both statistical and anecdotal analyses of crashes would need to be performed to facilitate informed public policy decision making and to allow vehicle manufacturers to make evolutionary refinements to airbag systems.

Three new NASS sites were selected: Dade County, Florida; Dallas County, Texas; and

multiple counties in Alabama. Investigators were hired and trained beginning in October 2001. Full case collection began in April 2002. The entire process is transparent, and data collected are available to all. A website has been established to facilitate public access to all materials generated by the BRP. Dr. Ferguson noted that the site contains minutes of all BRP meetings and all presentations made to and by BRP panel members. Dr. Ferguson also noted that largely through the efforts of the BRP, NHTSA now posts NASS cases on the web for viewing as soon as a preliminary review is completed by the NASS Zone Center. It is no longer necessary to wait up to 18 months to view the yearly NASS SAS file. Dr. Ferguson concluded her presentation by showing the URL for the website for the NASS case viewer.

Following her presentation, Dr. Ferguson introduced Dave Clark of the Ford Motor Company. Mr. Clark's presentation, "Advanced Restraints Technology," began with a review of the chronology of FMVSS 208 rulemaking. He stated that the 3 goals of the rulemaking were to 1) minimize risks; 2) optimize benefits; and 3) encourage innovation. The rulemaking, the most complex in NHTSA history, includes many new test requirements, new dummies, and new injury criteria. There are two regulatory options for minimizing risk: airbag suppression and low-risk deployment.

Mr. Clark presented Ford's Personal Safety System as an example of manufacturers' approaches to the use of advanced technology in occupant restraint systems. Such technologies include dual level inflation, electronic crash sensors, airbag acceleration-based predictive sensing logic, advanced deployment thresholds, seat track position sensors, safety belt buckle switches, belt pre-tensioners to remove slack, energy management seat belt retractors with load force limiters, and seat weight sensors. Modern electronic airbag systems have replaced the mechanical ball-in-tube crash sensors with electronic accelerometers to better discriminate crash onset and severity. The electronic control unit is the heart of these advanced systems. It processes all input from the various sensors and makes critical deployment decisions to fire one or multiple levels of airbag protection. The seat belt sensor indicating use may raise deployment thresholds while a sensed forward seat position would limit deployment to lower levels.

Advanced suppression technologies include seat-mounted weight detection sensors and seat-pattern-recognition sensors. Both systems would be used to either suppress deployment altogether or limit deployment to lower levels depending on the size and type of occupant or child restraint in the seat. The next iteration of advanced suppression technology may include spatial sensors, both infrared and sonic. These will be capable of determining not only the size and type of occupant in a seat but also where the occupant is located in proximity to the airbag module during the crash event. Mr. Clark concluded by showing the phase-in schedule for advanced airbags dictated by FMVSS 208.

Dr. Ferguson asked if there were any problems with the new technology. Mr. Clark responded that weight sensing technology currently is preferred due to the quality of the data, but there is a movement toward spatial sensors.

Dr. Ferguson introduced Mr. Robert Lange of General Motors Corporation (GM). His presentation, "Event Data Recorders," focused on GM systems and illustrated the systems used by other manufacturers. Mr. Lange led off by discussing an NTSB Directive to NHTSA asking for implementation of a plan to gather better information on crash pulses. The overall objective of this program is to provide accurate measures of crash severity for research purposes.

Mr. Lange explained that Event Data Recorders (EDRs) are not the "black boxes" used in aircraft. They contain neither lengthy records of an extensive array of pre-crash variables nor voice recordings. They are not designed to withstand extraordinary crash forces and post-crash events such as fire or immersion.

EDR rollout began in the early 1970s with the first GM airbag-equipped vehicles. Limited data were recorded by the systems of the early 1990s, and more extensive data are recorded by today's systems. Data may include speed, throttle opening, engine rpm, brake switch, seat position, seat belt buckle, airbag system time to deploy and level of deployment, and vehicle crash severity. The data record timeframe is up to 7 seconds before an event and up to 300 ms after.

The Society of Automotive Engineers (SAE) recently completed Recommended Practice J-1698 in record time. J-1698 specifies the vehicle event data interface (VEDI) so as to standardize access to EDR data. The SAE committee is considering future activity in this area. Potential users of EDR data include government agencies, safety agencies, and crash reconstructionists. The data also may be used to create a multidisciplinary driver database. Accuracy, reliability, and repeatability of the data are being addressed.

Following the presentation Dr. Ferguson asked, what is the reliability? Mr. Lange responded that there were problems with the seat belt indicator early on, but that the manufacturers are constantly checking and comparing EDR results to crash tests and NHTSA NCAP tests.

Dr. Ferguson introduced Chip Chidester, Chief of the Crash Investigation Division of NHTSA's National Center for Statistics and Analysis. Mr. Chidester's presentation, "Update on Data Available from the Special Crash Investigations and National Automotive Sampling System Programs on Frontal Airbags," led off with a brief discussion of the objectives of the frontal airbag data collection program at NHTSA. The agency is attempting to examine the safety impact of new and/or emerging occupant protection technology. Mr. Chidester first described the SCI data, which are published quarterly on the NHTSA website. He showed a bar chart of SCI data comparing children fatally injured by passenger airbags, normalized by registered vehicle years. The chart shows fatalities per million vehicle registration years have declined from a peak of 0.8 in 1996-97 to approximately 0.06 in 2002-03. A similar chart for driver fatalities showed a decline from a peak of 0.8 in 1990-91 to 0.05 in 2002-03. Mr. Chidester attributed this decline to changes both in airbag system design and

the success of the public information campaign, which has advised motorists not to let children ride in the front seat. The campaign has also emphasized the importance of adults using seat belts and sitting a safe distance from airbag modules. The next chart showed the adult fatality rate for barrier-certified vs. sled-certified driver airbags as of April 2004. The results are mixed; in some calendar years the fatality rate for sled-certified systems is lower while in other years the rate for barrier-certified systems is lower. In 2002-03 the fatality rate is 0.10 for barrier-certified and 0.3 for sled-certified airbags.

Mr. Chidester noted that SCI is not aware of a single case of fatal or life-threatening injury related to the deployment of a certified advanced complaint airbag system (CAC). Note: CAC airbag systems are certified to the new test requirements in FMVSS 208, which went into effect in September 2003.

Then Mr. Chidester described the data available from the NASS files, noting the number of cases from both CDS and Alliance-funded PSUs. He described the criteria used for collection of Alliance cases compared with NASS/CDS. The vehicles are newer and the more severe crashes are oversampled. Despite these differences the cases are fully compatible and can be used for statistical analyses when combined with the full NASS file. Since the inception of the program the number of vehicles meeting the criteria included 2,468 at the NASS sites and 832 at the Alliance-funded sites. Thus, there is a 34% increase in the number of the cases available for analysis of advanced restraint systems as a result of the cases from the Alliance-funded sites. The total number of cases where the delta V is greater than 25 mph was 98 in 2003, illustrating that only a small percentage of the cases meeting the criteria occur at higher crash velocities. Only 19 of these cases involved a vehicle with a CAC airbag.

Mr. Chidester went on to describe some of the new restraint/seat variables that have been added to NASS to capture data on advanced restraint system technology. Most noteworthy perhaps are data on event data recorders (EDRs), which will be critical to evaluating the performance of advanced systems. He described the new Oracle to SAS dataset which now includes 26 tables compared with the old SAS dataset of 11 tables. The NASS cases are now available for viewing as soon as the NASS Zone Center completes its preliminary quality control; interested parties no longer have to wait 18 or more months for the formal yearly SAS file. This speed-up was accomplished in response to the BRP's request for more real-time access to cases.

Dr. Ferguson asked for an explanation of the Oracle to SAS database. Mr. Chidester noted that it was merely an expansion of the data available for statistical analysis from the prior 11 tables to 26 tables.

Mr. Chidester remained at the podium for a second presentation, “NHTSA’s Program for Collecting Data on the Performance of Certified Advanced Compliant Air Bag Equipped Vehicles in Real World Frontal Crashes.” He began by describing the various notification sources the agency uses for selecting crashes for further review. The objectives of the CAC investigations are to examine the safety impact of rapidly changing technology and to provide data for assessing the real-world performance of these vehicles. The agency is working with manufacturers to learn the specifics of these new technologies and is pursuing cases covering a wide range of crash scenarios. A crash must involve a 2003 or newer model vehicle, which must be available for inspection.

Mr. Chidester indicated that readout of the EDR by crash investigators would be critical to the successful analysis of airbag system performance. In the case of airbag systems with multiple stages of deployment, for example, it will not be possible to know what stages deployed without the EDR readout. Mr. Chidester said that a cooperative effort between NHTSA and the automobile industry is allowing crash investigators to download and interpret EDR data. Field investigators can download EDR data from most GM vehicles and some Fords. Since 2003 SCI has investigated 65 CAC cases involving vehicles across many passenger car, light truck, and SUV lines. Data are published quarterly on the NHTSA website: http://www.NASS.nhtsa.dot.gov/BIN/NASSCASELIST.EXE/SETFILTER.

Mr. Chidester ran through a sample case involving a 2003 Chevrolet K1500 pickup striking a 1997 Honda Accord at an intersection. He showed the details of the EDR readout describing the deployment characteristics of the driver airbag, which allowed investigators to determine that only the first stage of the driver airbag had deployed early in the crash event.

Dr. Ferguson introduced Chuck Hurley from the National Safety Council (NSC.) Mr. Hurley’s presentation, “Public Opinion on Air Bag Risks,” noted that NSC has been conducting public opinion polls for some time to judge the general awareness of the dangers of airbags. He remarked that respondents have continued to be positive about driver airbags despite all the negative publicity. Negative impressions about passenger airbags peaked in December of 1996 at 41%.

Public information campaigns about the need to put children in the back seat of passenger airbag-equipped vehicles have been very successful. Seventy-eight percent of people polled in December 1996 were not aware that children 8 and older should ride in back. By June 2001 this proportion had declined to 18%. In a poll conducted in January 2004, lack of awareness that kids 0-12 years old should ride in rear seats was 6% overall. This poll oversampled African-Americans and Hispanics and indicated that their lack of awareness was 11% and 7%, respectively. Mr. Hurley noted that the 6% overall lack of awareness equates to 3.3 million children still riding in the front seats of airbag-equipped vehicles.

A study of the benefits of seat belt use by the Highway Safety Research Center at the University of North Carolina revealed that the most dramatic reduction in injuries and fatalities occurs at the upper end of belt use, above 80%. Apparently occupants who are most likely to be involved in serious crashes are the last ones to buckle up. Mr. Hurley repeatedly emphasized the importance of enforcement to raise belt use. He also emphasized the importance of passing primary enforcement belt use laws to give law enforcement a mandate to conduct effective programs.

Dr. Ferguson asked if there was concern about lack of awareness of airbag dangers for second owners of airbag-equipped vehicles. Mr. Hurley noted that this will be a problem until the entire fleet has depowered airbags. Dr. Durbin asked if NSC will track public perception about whether there is a reduced need to put kids in the back with the new generation of advanced airbags. Mr. Hurley said NSC will continue to track public perception. Henry Jasney asked what the seat belt mobilization will do in states with secondary enforcement belt laws. Mr. Hurley responded that the focus of enforcement will be on high-risk groups such as teenagers and on child restraint use since all states have enforceable laws.

A member of the audience noted that the TV show, Dateline, recently presented a segment on racial profiling by law enforcement and asked if this was a concern. Mr. Hurley said this is a very difficult issue. Enforcement must be fair and strict to gain the confidence of minorities. He said he believed that the vast majority of law enforcement personnel do an excellent and fair job of enforcement.

Joan Claybrook asked if automobile dealers had been enlisted to help get the message out on restraint use. Mr. Hurley said it was very difficult to get the message out in dealer lots, and we need to find more effective ways.

Ms. Claybrook asked if built-in child restraints have benefits and whether they should be standard equipment. Mr. Hurley said he thought they did have benefits, but unfortunately the market is not supporting their use. Dr. Durbin noted that their research has found the same effectiveness for injury reduction for built-in child seats as for other child restraints.

Dr. Ferguson introduced Dr. Kristy Arbogast, Associate Director of Field Engineering, TraumaLink at The Children's Hospital of Philadelphia. Dr. Arbogast's presentation, "Variation in Performance of Second Generation Air Bags for Child Occupants by Type of Vehicle," noted analyses showing that the overall injury risk to children nearly doubles for those exposed to passenger airbags. The landscape has been changing, however, through educational focus on getting kids in rear seats and through design changes to airbag systems. Exposure is changing; 18% of 4 to 8 year-olds sat in the front seat in 1998, but only 10% do so today. Still we have double the number of children exposed due to increasing numbers of airbag-equipped vehicles.

The overall AIS-1 (minor) injury rate is the same for first and second generation airbags. The serious injury rate has declined by 41% for second generation airbags compared to

first generation. Reductions have occurred in cars, minivans and pickup trucks, but there has been an increase in injury rates in SUVs. The percentage of injury by body region is similar across vehicle types, with SUVs having slightly more head and upper extremity injuries and appreciably fewer facial injuries. The higher injury risk in SUVs is among older kids, with the rate for 3 to 8 year-olds going down for second generation airbags.

The passenger car deployment rate has dropped from 11% in first generation airbags to 7% in second generation airbags. Similar reductions have been found for other vehicle types. Dr. Arbogast emphasized that we must continue to get the message out that older children belong in rear seats because airbag-equipped vehicles now are being driven by subsequent owners in different socioeconomic subgroups that may not be as aware of the importance of placing children in rear seats. New designs may carry conflicting messages for consumers if automobile manufacturers tout the lifesaving advantages of the new designs and studies show injury reductions. The popularity of SUVs as family vehicles is a concern if the trend of increased injury potential continues.

Following the presentation, Jim Simons noted that since the deployment threshold is higher for SUVs, maybe second generation airbags work well at low speeds but not as well at high speed. Dr. Arbogast responded that it was an interesting theory, but CHOP has not teased that out of the data.

Dr. Ferguson introduced Dr. Elisa Braver from the National Study Center for Trauma and EMS, University of Maryland School of Medicine. The sources of Dr. Braver's presentation, "Driver Deaths in Frontal Crashes: Comparisons of Older and Newer Airbag Designs," were the Fatality Analysis Reporting System and the R.L. Polk registration data. All types of light duty vehicles (171 makes and models) with basically unchanged designs during 1997-99 were studied. Rate ratios for driver deaths in model years 1998-99 were compared to the 1997 model year. When excluding pickups, there was an 11% decrease in fatality rate for the later model year vehicles. Later model pickups had a 35% increase in the fatality rate. Among passenger cars, the biggest reduction was for midsize, less for small cars and not much for large cars. The decrease was greatest for females versus males but was not statistically significant. A decrease occurred for 15 to 59 year-olds, but there was essentially no change for over 60 year-olds. Reductions occurred for both belted and unbelted occupants.

Dr. Durbin asked if the pickup result was due to a small number of data. Dr. Braver responded that the data samples for pickups and SUVs were similar.

Dr. Ferguson announced that she would deliver a presentation on behalf of Dr. Maria Segui-Gomez, who was unable to attend. The presentation, "Changes in Injury Patterns in Frontal Crashes: Injuries to Drivers of Vehicle Model Year 1993-1997 vs. Drivers of Vehicles 1998-2003,"used 1993-2003 NASS/CDS data to evaluate whether there have been any detectable changes in the frequency and severity of injuries to drivers of 1998 and newer model vehicles in frontal crashes. Bivariate statistical analyses showed that the likelihood of sustaining a MAX AIS of 2 or greater in towaway frontal crashes was

24.6% for MY 93-97 vehicles versus 20.4% for MY 98-03 vehicles. The respective numbers for MAX AIS of 3 or greater were 12.2% and 9.5%. Injury reductions occurred at all crash velocities and for both males and females. The deployment rates were lower for the 1998 and newer vehicles at all crash velocities.

Logistical regression analyses showed that MY 1998-2003 drivers were less likely to sustain MAX AIS 2+ and MAX AIS 3+ than MY 1993-1997 drivers, even when controlling for confounders and other covariates. These differences are borderline or disappear if the analysis is restricted to frontal crashes or crashes where the airbag deployed; the likely reason is small sample sizes.

Dr. Ferguson introduced Dr. Larry Schneider from the University of Michigan Transportation Research Institute (UMTRI). Dr. Schneider's presentation, "Comparison of Frontal-Crash Protection for Front-Seat Occupants in Pre-1998 and 1998+ Model-Year Vehicles," described an in-depth crash investigation program that has been ongoing at the University of Michigan for 35 years with sponsorship from the Alliance and its predecessor organizations. The investigations focus on moderate to severe crashes involving late-model vehicles. The database resulting from crashes investigated since 1990 has been used to compare variable distributions and perform logistical regression analyses to compare the frontal crash protection provided by pre-1998 and 1998 and newer model vehicles. The analyses are attempting to answer two key questions: Do 1998 and newer airbag systems have reduced injury potential? Is there any change (reduction) in frontal crash protection, especially for unbelted occupants, in moderate to severe frontal crashes?

The distribution comparisons for all drivers show that crash, vehicle, occupant, and restraint variables in the pre-1998 and 1998 and newer models match extremely well except for vehicle type and mass. Although the distributions of vehicle type and vehicle mass show higher percentages of heavier SUVs and pickup trucks in the 1998 and newer vehicle dataset, the distributions of crash severity for the two datasets are nearly identical.

Dr. Schneider then showed comparisons of distributions of maximum injury severities (i.e., MAIS) for different body regions and various combinations of body regions for all drivers in the pre-1998 and 1998 and newer model vehicle datasets. The injury distributions for the two groups were not significantly different, although drivers in the pre-1998 vehicles sustained marginally greater frequencies of severe neck injuries. Distributions of the maximum injury severity (MAIS) for the five body regions that belt and airbag restraint systems are designed to protect (head, neck, face, chest, and abdomen) are nearly identical for the pre-1998 and 1998 and newer vehicles.

Dr. Schneider proceeded to show similar comparisons of independent and dependent (MAIS) variable distributions for unbelted drivers. The results are similar to results for all drivers. That is, the independent variables except for vehicle type and mass were very well matched. The distributions of MAIS for the combined regions of head, face, neck, chest, and abdomen were nearly identical, although the data for unbelted drivers of the

pre-1998 vehicles show somewhat higher percentages of drivers with severe neck and chest injuries. Interestingly, the injury data for unbelted drivers of 1998 and newer vehicles show higher frequencies of serious forearm, elbow, wrist, and hand injuries and higher frequencies of moderate-to-serious knee, thigh, and hip injuries that are marginally significant.

Multivariate analysis of these data shows that the best predictors of serious injuries to drivers in frontal crashes of airbag-equipped vehicles are crash severity, seat belt use, and driver age. Logistical regression models developed separately for the two sets of data show that unbelted drivers are much more likely to sustain serious injuries to the head, face, neck, chest, and abdomen in frontal crashes than are belted drivers. The probability of a driver sustaining an MAIS$\geq$3 injury to these body regions at any crash severity is greater for the pre-1998 vehicles compared with 1998 and newer vehicles. Although these differences are not statistically significant, the relationship of the injury-probability curves is consistent across all driver ages and for both belted and unbelted drivers. The regression models also indicate that differences in injury probability curves for the two model year datasets are largest for unbelted drivers compared with belted drivers, suggesting that later-model airbag-equipped vehicles are offering better protection to the head, face, neck, chest, and abdomen of unbelted drivers. Also, the probability of sustaining an MAIS$\geq$3 injury increases when the upper and lower extremities are included in the models, and the probability curves for the two datasets become nearly identical.

Dr. Schneider's analyses included a preliminary statistical comparison of frontal crash protection for adult passengers in the right front seat. Results are not statistically different from those for drivers. They indicate that the head, face, neck, chest, and abdomen of passengers are being offered similar or better protection in frontal crashes of 1998 and new model vehicles compared with pre-1998 vehicles. However, the results for passengers do not show the same trend of higher risk of extremity injuries in 1998 and newer model vehicles.

Dr. Schneider concluded with the following observations:

> 1) Frontal crash protection for the head, face, neck, chest, and abdomen (5 airbag regions) is at least as good in 1998+ MY vehicles (primarily equipped with depowered airbags) as in pre-1998 vehicles for belted and unbelted drivers and adult-size right-front passengers-many "success stories."
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> 2) There continue to be very few frontal crashes in which an unbelted driver and/or right-front passenger sustained AIS 3+ injuries due to "overpowering" a 1998+ airbag.
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> 3) Airbag protection for unbelted drivers and right-front passengers is limited by occupants getting around and/or over the airbag.
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> 4) Airbags in 1998 and newer models appear to be less injurious but can still

cause serious-to-fatal injuries to out-of-position occupants.

5) The only body regions that appear to be at greater risk of injury in frontal crashes of 1998 and newer vehicles are the extremities.

Dr. Ferguson introduced Jeffrey Augenstein, M.D., Director of the William Lehman Injury Research Center at the University of Miami, who described crash studies. The Ryder Trauma Center is a Level I, treating only the most severely injured occupants of vehicle crashes as well as other severe trauma cases. The center investigates very severe crashes through funding provided by the DOT-sponsored Crash Injury Research and Engineering Network (CIREN) program.

Dr. Augenstein described the enormous future potential that exists for improved diagnosis and treatment of trauma victims through Automatic Collision Notification (ACN). ACN uses cellular phone technology to notify the trauma center that a serious crash has occurred and to supply the vehicle location and crash parameters. The voice link can be used to dispatch rescue personnel and provide comfort to crash victims. Dr. Augenstein believes the major benefit will come from using the crash parameter data in the event data recorder. These data can be run through an algorithm that can predict likely injury patterns based on the characteristics of the crash. Emergency personnel will already have an indication of the likely injuries and treatment protocol before arriving at the crash scene.

Dr. Augenstein introduced Dr. Kennerly Digges, Director of Biomechanics and Safety Research, FHWA/NHTSA National Crash Analysis Center at George Washington University, to present findings from crash research at the Lehman Center. Dr. Digges' presentation, "Using CIREN Data to Assess the Performance of the Second Generation of Air Bags," described the attributes of the NASS/CDS cases by crash and injury severity. He concluded by showing that MAIS 3 and higher nonfatal and fatal injuries comprise approximately 2% of the total NASS cases. For the Ryder trauma center cases, 50% are MAIS 3+ and 25% are fatal. Dr. Digges surmised that if the MAIS 3+ fatal and nonfatal injuries were considered as "failures" and the remaining 98% with MAIS 2 or less as successes, this could be equated to the 75% failure rate (MAIS 3+ and fatal) in the trauma center cases for analysis purposes.

Dr. Digges showed a chart of driver fatality rates by delta V for first generation airbags and noted that the rate was higher than expected at the lower delta Vs. There were 9 fatalities at delta Vs of less than 20 mph (4 to short stature occupants, 4 to older occupants, and 1 due to intrusion/incompatibility). He concluded that first generation airbags were too stiff for occupants in close proximity to the deployment and too stiff for older people. For second generation airbags there were no fatalities below 25 mph. A chart comparing the fatality rate of old and new airbags at different crash velocities showed that the new airbags had lower fatality rates at all crash velocity groupings. Dr. Digges observed that, for second generation airbags, no elderly fatalities had occurred below 30 mph delta V; no short-stature fatalities had occurred below 30 mph delta V; and new driver airbags appear to be working well for restrained drivers at all crash

severities and for unrestrained drivers in crashes less than 25 mph.

Dr. Digges showed a chart comparing the fatality risk to passengers exposed to old and new airbags by delta V. At the lower speeds the new airbags had a lower risk, but this transitioned to higher risk at the higher velocities. He noted that belt use was 52% for the occupants exposed to the older airbags versus 36% for the occupants with newer airbags. A similar chart for unbelted occupants still showed a higher risk for the occupants exposed to the new airbags at delta Vs of 25+ mph, although the risk was high for both old and new airbags. The observations for second generation passenger airbags were no child fatalities; no close-in fatalities in low-speed crashes; no elderly fatalities below 30 mph delta V; and high fatality rates above 25 mph for unrestrained (both old and new airbags). Dr. Digges then showed an example case involving an 18-year-old male driver of a Honda Element who survived a 44 mph impact with a tree.

Following the presentation, Mike Finkelstein asked if the higher risk in high-speed crashes means the airbag is overpowered. Dr. Digges answered that he believes the depowered airbag performs fine in straight ahead crashes but not as well in angled impacts.

Dr. Ferguson returned to the podium and thanked all the speakers for excellent presentations and thanked the Alliance for providing such a splendid facility for the BRP Public Meeting. She then summarized the day's activities:

As a result of the additional resources committed by the Alliance, we are now collecting NASS/CDS cases at a much faster pace. To date the program has collected data on 2,468 case vehicles involved in frontal crashes (without rollover) appropriate for analysis of airbag performance at the existing NASS/CDS PSUs. The Alliance funded PSUs added an additional 832 case vehicles for an increase of 34% in available data.

Overall we see that second generation airbags are doing a good job, as shown in the NASS/CDS data, FARS data, SCI data at NHTSA, UMTRI and WLIRC, CIREN data and CHOP data. There has been no cataclysmic reduction in the effectiveness of airbags as some had predicted; indeed, most statistical analyses conducted to date indicate a small, but measurable, increase in effectiveness. The FARS analyses conducted by Dr. Braver indicate overall improved protection against fatality for drivers. Similarly the NASS/CDS data analyzed by Dr. Segui-Gomez show that drivers in frontal crashes with second generation airbags sustain significantly fewer and less severe injuries than drivers with the earlier airbags. Head, chest, and abdominal injuries all seem to be down. There is some evidence, albeit very preliminary, that some body regions (notably the upper and lower extremities) may be experiencing an increase in injury with the second generation airbags. We will need to watch this very closely to understand these data better and to confirm these early impressions.

During its initial deliberations on the type and quantity of data needed to answer questions about changes in overall airbag effectiveness, the BRP performed "power analyses" (estimates of the quantity of data required to produce statistically significant

results, assuming certain levels of change in airbag effectiveness). These analyses showed that we could detect wholesale changes in effectiveness (on the order of 20%) within one year using NASS/CDS data. Thus, the BRP is confident that we would have seen evidence of such a decline, had it occurred, even at this early stage of data collection.

There is now a body of evidence that depowered and advanced airbag systems have dramatically reduced the harm to out-of-position children and adults in low-speed crashes, which was an area of grave concern. Chip Chidester presented data showing that the fatality rate for children per million registered vehicle years has dropped from a peak of 0.8 in 1996-97 to 0.06 in 2002-03. Similarly, the rate for adults has declined from a peak of 0.8 in 1990-91 to 0.05 in 2002-03.

The data show that while airbags appear to work very effectively when the collision forces are straight ahead, occupants can get around or over an airbag in many off-center collisions. While data on truly advanced airbag systems are sparse, they are encouraging. The NHTSA SCI program is not aware of any cases with a fatal or life-threatening injury related to the deployment of a certified advanced compliant airbag.

The data have been reviewed from a statistical standpoint and also anecdotally on an individual case basis. The BRP has believed from the outset that both types of analysis are critical to understanding how to improve the performance of airbag systems. Statistical analyses will tell us the overall long-term efficacy of regulatory changes and the manufacturers' responses. However, it will be many years before we can understand the effect of individual technologies such as new arrays of crash sensors or multiple levels of deployment; we will need to continue with case-by-case anecdotal analyses to give us an early readout of how these technologies are performing in particular crashes.

EDRs will be important in helping crash investigators to understand the nuances of advanced airbag system performance. For example, without EDR readout it will likely not be possible to determine which stages deployed in multistage inflators. Fortunately, we have heard today that great progress has been made in joint industry/government programs to get crash investigators the tools they need to read and interpret EDR recordings where this information is available.

Public information programs have been very successful at getting caregivers to put children in the back seat of passenger airbag-equipped vehicles. However, the awareness level is not as high for some minority groups as it is for the overall population. We must continue to get the message out because vehicles are being driven by subsequent owners in different socioeconomic subgroups that may not be as aware of the importance of placing children in rear seats of airbag-equipped vehicles, and new designs may carry conflicting messages for consumers if automobile manufacturers tout the lifesaving advantages of new designs and studies show the reduction in injury for new designs.

As researchers, our perennial lament is that we do not have enough data. The good news is that more data are coming at a faster rate than ever. We look forward to analyzing new data as they become available. We will reconvene about a year from now to reconsider what we are finding.

Dr. Ferguson thanked NHTSA observers, Dr. Carra and Mr. Chidester, for all they have done. NASS/CDS crash investigation data now are available on the web on a real-time basis and programmatic changes have been made to facilitate more detailed analyses using the Oracle to SAS database and other tools.