MEMORANDUM

TO: All Invited Participants to June 22, 2000 Meeting

CC: Side Airbag OOP Injury Technical Working Group

FROM: Adrian K. Lund
Chairman, Side Airbag OOP Injury Technical Working Group

SUBJECT: Summary of Invited Meeting Comments and Response of the Technical Working Group

DATE: August 8, 2000

The Side Airbag OOP Injury Technical Working Group (TWG) would like to express its appreciation to all those who provided comments regarding the draft *Recommended Procedures for Evaluating Occupant Injury Risk from Deploying Side Airbags*. A list of invited participants, a list of participants attending the meeting or submitting written comments, and a summary of comments received are attached to this memorandum.

Most of the comments and questions concerned clarification of the test procedures, and there seemed to be general support for the draft *Procedures* as a good representation of current knowledge about testing for OOP occupant injury risk from side airbags. Nevertheless, there were some questions raised that led to further discussion and some changes to the draft. These are as follows:

1. Some questions concerned dummy test positions, particularly whether the proposed positions were “worst case.” The TWG has considered this issue extensively, and there are two important points that must be recognized:
    a. The proposed test procedures are intended to be used together, as a whole, to provide a thorough evaluation of the airbag system. While each individual test position may not, in and of itself, represent the 'worst case' condition for every system, the TWG is confident that any system found to conform to all of the requirements set out in this document will pose a minimal risk of injury to OOP occupants.
    b. Second, the procedures specifically note that the recommended tests provide a standard starting point for evaluating OOP occupant injury risk but that “engineering judgment” must be used to assess whether additional testing might be necessary, given the specific design of a particular system.
2. Aloke Prasad of NHTSA and Frank Pintar of the Medical University of Wisconsin both asked if it would not be generally more effective (more “worst case”) to put the head directly in front of the deploying seat-mounted side airbag. In fact, testing conducting by members of the TWG showed that positions included in the recommended test procedures are often more sensitive to possible injury risk, usually because they exercise the neck load cells and the neck injury criteria are very sensitive. Nevertheless, the TWG recognizes there are still outstanding questions in this regard and the performance of the recommended test procedures will be reviewed when the TWG is reconvened in 2001.
3. Comments by Aloke Prasad of NHTSA indicated that there might be some confusion about the test procedures, particularly with regard to the forward-facing

3- and 6-year old dummies in vehicles with seat-mounted airbags. Specifically, Mr. Prasad indicated that NHTSA, which is studying the recommended procedures, was trying to keep the dummy's pelvis against the seat bight. However, the procedures actually specify that the dummies' legs and pelvis be pulled forward until the proper relationship is achieved between the top edge of the airbag and the dummies' necks.

4. Matthew Bevan of Johns Hopkins University raised several questions about the positioning of the dummies. Although he felt the TWG's rationale was explained in the meeting, he stated strongly that the TWG needed to make its test procedures and rationale more readily understandable to the public. The TWG understands this concern, and it will try hard to do this in future public venues. As a very modest beginning, the TWG is inserting language in the document that addresses one of Bevan's questions, whether the lack of a center console might affect dummy kinematics and subsequent likelihood of striking other objects in the vehicle. The new language will make clear that the TWG's procedures do not address subsequent dummy impacts in a vehicle because the most serious injury risk occurs when the side airbag initially deploys into an OOP occupant.
5. Roger Nightingale and Barry Myers of Duke University provided extensive comments on neck injury criteria used by the TWG, including new experimental data. Priya Prasad reviewed the comments at the invited meeting and noted that the data provided by the Duke researchers was very new and expressed concern that the strength estimated for the various neck joints could be misleading when applied to the neck as a whole. The TWG decided no revision of the proposed neck injury reference values was warranted at this time, but the TWG will continue to monitor the Duke research.
6. In written comments, Tom Baloga of Britax recommended that the TWG refrain from calling the cushions used to raise dummy seating heights "booster seats", lest the public think they really were booster seats. The TWG has adopted Mr. Baloga's suggestion of calling the cushions "booster blocks."
7. Mr. Baloga also indicated that OOP tests should be conducted at ambient temperatures consistent with the highest temperatures that might be experienced by the side airbag modules in actual use. The TWG recognizes Mr. Baloga's concern but believes this point is addressed in its statement that automakers must exercise engineering judgment regarding whether their tests have assessed the OOP injury risk of their airbag system.

In addition to these issues that were raised by commenters, the TWG had also indicated its intention to review its injury reference values with respect to the injury criteria specified in NHTSA's recently published rule on advanced airbags. Specifically, the TWG draft injury reference values and those of NHTSA differ with regard to neck injury risk assessment, head injury risk assessment, and chest injury risk assessment. Harold Mertz of General Motors gave a summary of the differences in neck injury measures at the invitational meeting. Subsequently, the TWG decided to adopt the neck N_{ij} criterion and the peak neck tension and peak neck compression criteria that were proposed by the Alliance and specified by NHTSA in FMVSS 208 for frontal OOP regulation. The TWG agreed that the limits on these neck criteria would achieve similarly low levels of OOP neck injury risk as the neck injury reference values initially proposed by the TWG.

With regard to the chest injury reference values and head injury reference values, the TWG elected to retain its recommendations. The TWG still sees no scientific justification for the inclusion of chest acceleration, but will monitor this injury value for research

purposes. Similarly, the TWG still feels it is appropriate to scale the HIC (head injury criterion) values according to the size of the dummies, in order to retain the stated purpose of keeping severe injury risk to no more than 5 percent (in the event the occupant is out of position). It is unclear to the TWG why NHTSA scaled the HIC values in some cases and not others.

Summary

In closing, I would like to repeat the TWG's thanks for the effort that many of you made to help us complete this document. I hope that we can count on your further participation when the TWG is reconvened in 2001 to review how well the *Recommended Procedures* is working in the design of new systems. In the meantime, if any of you have information or concerns of which you think the TWG should be made aware, please do not hesitate to contact me or a representative of one of the other sponsoring organizations (AAM, AIAM, AORC). We, like all of you, are most anxious that these Procedures be effective and that the current very positive real world experience with side airbags continues.

Appendix I

Invitees Attending June 22, 2000 Meeting or Commenting on Draft Procedures

Advocates	Ms. Judie Stone
America Pacific	Mr. John Gibson
ARC	Mr. Richard Husband
BF Goodrich	Mr. Bob McClenathan
Britax	Mr. Thomas Baloga *
Childrens Hospital of Philadelphia	Dr. Kristy Arbogast *
Duke University	Dr. Barry Myers *
Graco	Mr. Steve Gerhart
JHU/APL	Dr. Matt Bevan *
Magna Seating	Mr. Kevin Ventura
Medical College of Wisconsin	Dr. Frank Pintar *
National Safe Kids	Dr. Heather Paul
National Transportation Safety Board	Mr. Vernon Roberts
NHTSA	Mr. Joseph Kanianthra
NHTSA	Dr. Tom Hollowell
NHTSA	Mr. Chip Chidester
NHTSA	Mr. Matt Maltese
NHTSA	Dr. Shashi Kuppa
NHTSA	Ms. Randa Radwan Samaha
NHTSA/VRTC	Mr. Aloke K. Prasad *
NSC	Mr. Chuck Hurley
Parents for Safer Airbags	Mr. Rob Sanders *
Safe Kids	Ms. Camilla Taft
TRW	Dr. Ayad Nayef

* Made oral presentation or submitted written comments.

Appendix II

People invited to meeting June 22, 2000

Advocates for Highway and Auto Safety	Ms. Judie Stone
Airbag and Seatbelt Safety Campaign	Ms. Janet Dewey
American Academy for Pediatrics	Dr. Marilyn Bull
American Automobile Association	Mr. Mark Edwards
American Trauma Society	Mr. Harry Teter
Aprica U.S.A., Inc.	Mr. Terry Nishyma
Automotive Coalition for Traffic Safety	Mr. Philip Haseltine
Britax Child Safety, Inc.	Mr. Thomas Baloga
Center for Auto Safety	Mr. Clarence Ditlow
Century Products Co.	Mr. David Campbell
Chicco USA, Inc.	Mr. Daniel Orsini
Childrens Hospital of Philadelphia	Dr. Flaura K. Winston
CIREN Centers	Dr. Jeffrey Augenstein
Consumers Union	Ms. Sally Greenberg
Cosco Inc.	Mr. Jon Reynolds
Duke University	Dr. Barry Myers
Evenflo Co., Inc.	Mr. Ronald Moran
Fisher-Price	Mr. Paul Charland
George Washington University Hospital	Dr. Til Jolly
Graco Children's Products	Mr. Steve Gerhart
Harvard Center for Risk Analysis	Dr. John Graham
Johns Hopkins University	Dr. Matthew Bevan
Kolcraft Enterprises, Inc.	Mr. Tom Koltun
Medical College of Wisconsin	Dr. Frank Pintar
Nat'l Assoc. of Governor's Hwy Safety Representatives	Ms. Barbara Harsha
National Safe Kids	Dr. Heather Paul
National Safety Council	Mr. Chuck Hurley
National Transportation Safety Board	Mr. Jim Hall
Parents for Safer Airbags	Mr. Rob Sanders
Public Citizen	Ms. Joan Claybrook
Rand International	Mr. Steven Goldmeier
Safeline Corporation	Mr. Tim Weeks
University of Michigan Traffic Research Institute	Dr. Larry Schneider
University of Virginia Auto Safety Lab	Dr. Jeff Crandall
Wayne State University	Dr. Al King

Appendix III

Summary of Comments (Both Written and Oral)
Invited Comments Meeting, June 22, 2000

Scott Schmidt, Alliance of Automobile Manufacturers

Mr. Scott Schmidt in his statement gave credit to the TWG for its impressive achievement in developing such a comprehensive set of procedures in such a short period of time. He noted that Adrian Lund, the chairman of the TWG, deserves a lot of credit for its success. However, he noted, Adrian's already challenging task would have been impossible had there not been a fundamental shift in the way government, industry, suppliers, academia, insurance and other safety groups have begun to work together to tackle some of these difficult safety issues.

He also reiterated the Alliance commitment to not only support the development of these guidelines but to develop side air bag systems in accordance with these guidelines. However, since the procedures have not been finalized, it is premature to attempt to comment on any implementation timing. Individual members will come forward and provide that information when the procedure are finalized.

Mike Cammisa, Association of International Automobile Manufacturers, Inc.

Mr. Mike Cammisa, in his statement, reiterated the point that real world experience with side air bags has thus far been very positive and that the process of combining the experience of the members of the working group to develop these recommended procedures will contribute to the continuation of this positive experience.

He also reiterated AIAM's commitment to the process and looked forward to the availability of a final set of recommendations. However, he stated that the specific plans for how and when to implement these procedures will be developed by the individual manufacturers once the recommendations have been finalized.

AIAM members will continue to participate in the TWG efforts to update the recommended procedures to ensure that they remain current as more field data become available.

Greg Bayley, George Kirchoff – Automotive Occupant Restraints Council (AORC)

Mr. Bayley reiterated AORC member support for both the TWG process and it's draft recommended procedures. He also noted that many of their members were already utilizing the recommendations as preferred industry practice.

Aloke Prasad – National Highway Traffic Safety Administration

Dr. Aloke Prasad representing the National Highway Traffic Safety Administration presented a summary of NHTSA’s side air bag research. NHTSA’s side air bag research has two primary focuses; to evaluate the risk to out of position children and small adults from the deploying air bag, and to evaluate the protective capability/benefits of side air bags in side impact crashes.

With respect to NHTSA’s work evaluating the risk to OOP occupants, NHTSA has developed a test matrix that not only evaluates the TWG procedures but also explores additional variations of these procedures to identify any additional “worst-case” positions. The aim is not to test every vehicle but just a representative sample encompassing the available technologies (door, seat, and roof mounted).

While the TWG procedures do not specify any infant testing, NHTSA's testing includes several positions using the CRABI dummy. To-date this testing has shown that side air bag systems are relatively benign for infants in child seats (front passenger seating position).

During testing with the three year old, Aloke noted that when the dummy's pelvis is flush up against the seat back (depending upon the seat geometry) the natural layout of the head neck assembly puts the head a few inches away from the seat back. It was Aloke's opinion that this did not represent the "worse-case" and that the dummy pelvis should be moved away from the seat back until the head contacts the seat.

In addition, he felt that there were instances where the height of the head relative to the air bag module in the TWG procedures was not necessarily the worst case and that the dummy should be moved to place the head/neck into closer proximity/alignment with the air bag.

Given the fact that injury risk appeared to be quite sensitive to dummy orientation to the air bag, and that each vehicle model has the air bag positioned in somewhat different locations, Aloke envisioned significant challenges to the development of a set of generic seating positions that would cover everything in the worst case.

With respect to NHTSA evaluation of the benefits from side air bags, they will be running two sets of tests; those with the air bag and those without (baseline). Based on these "matched pairs" NHTSA will calculate benefits. NHTSA asked for some industry assistance identifying suitable vehicles where such comparisons would be valid.

While not within the scope of the TWG, Aloke mentioned some of the difficulties he encountered getting correct replacement parts and accurate repair information.

Kristy Arbogast – Children's Hospital of Philadelphia (CHOP)

Dr. Arbogast prefaced her presentation with a statement commending the working group for its comprehensive, realistic, and timely evaluation of what is a complex issue.

She discussed three primary observations from the collaborative work being done by State Farm, CHOP, and the University of Pennsylvania focusing on how children are injured in motor vehicle crashes.

Her first observation was that there is very limited field experience of side air bag deployments. In fact within her study there was only one crash that involved deployment of the side air bag. In this case, the occupant, a very large 11 year old male, received minor injuries from the frontal air bag (which also deployed) but no obvious adverse interaction with the deploying side air bag was evident.

Her second observation was that her analysis of children receiving concussions corresponded to a HIC of about 625 with lateral head acceleration of 72 g's. She indicated that this provided some confirmation of the TWG's selected HIC reference values, which were designed to address more serious head injuries.

Her last point, while not directly relevant to the side impact test procedures, was to discuss how children were being injured in side impacts. Unlike the adult population, she found that almost half of the serious injuries occurred in crashes with little or no intrusion. And the injuries sustained were dominated by head injuries. After head injuries the next dominant injury mode involved abdominal injuries.

Based on these conclusions, she challenged the group to develop the tools (dummies) and injury measures to better address the injury risk for both the head and abdomen.

Matthew Bevan, Johns Hopkins University – Applied Physics Laboratory

Dr. Bevan submitted written comments to the TWG prior to the technical review meeting. In his written comments Mr. Bevan expressed concern that the dummy kinematics and measurements might be influenced by the lack of a center console (which is present in many vehicles).

His other written comments questioned whether the working group considered possible positions where children would be sleeping in the front seat laying on their side with the head on the armrest and in the front seat with out a booster seat (which may bring the head closer to the deploying air bag).

In Dr. Bevan's verbal presentation he thanked the working group for their efforts to head off a potential problem before it becomes a real problem. He also acknowledged the inherent difficulty of the working group's task.

One of his primary points is that there is a significant amount of work (and complexity) involved with this effort that is not apparent to the lay person reading the procedure. In fact, he stated that many of his questions (comments) were answered in the course of the morning presentations. However, he felt that the group needed to do a better job explaining the procedures, what they cover, and how they were developed in terms that the lay person could understand.

His final recommendation was that the test dummies be designed to be able to measure injury risk when the head is slumped to the side (as in sleep).

Tom Bologa – Britax

Tom Bologa (who was not in attendance) submitted written comments to the work group prior to the technical review meeting. In his written comments he thought that it was important that we remind the public that we are not recommending that children travel in these positions. He also suggested that to avoid consumer confusion, the group replace the term "booster seat" with "booster block". His last recommendation was that the procedures should specify that testing be conducted at the high temperature appropriate for the conditions expected.

Dr. Barry Myers, Dr. Roger Nightingale – Duke University

Dr. Barry Myers and Dr. Roger Nightingale (who were not in attendance) submitted written comments to the work group prior to the technical review meeting. In their written comments they address the biomechanic injury tolerances of the neck in torsion, flexion, extension, and lateral bending.

With respect to torsion neck tolerances they note that dummy necks, unlike the human necks that they model, are considerably stiffer in torsion and thus the dummy generates large torques quickly. While they observe that torsional neck injuries are clinically rare, they also note that the out-of-position side impact exposure is unique and creates forces and axial torques which are typically not encountered in any other injury environment. Therefore, they state that it is unknown whether torsion will be a source of neck/spine injury in this environment. However, if injury does occur, it is likely to be to the upper cervical spine.

With respect to flexion, extension, and lateral bending tolerances they have been researching the moment generating capacities of the cervical spine musculature. The rationale is that the injury tolerance of the cervical spine must be greater than the moment generating capacity of the muscles. As part of this effort they have developed a computational model that calculates the lines of action and moment generating capacities for all of the major muscle groups. They presented tables containing the resisting moments in flexion, extension, and lateral bending about the joints of each motion segment and the moments in extension and lateral normalized with

respect to the flexion tolerance. They note that these numbers are in reasonable agreement with the Alliance proposal, which the TWG has adopted, with the exception of those at OC1 and C7-T1.

Finally they looked at the combination of muscle tolerance and ligamentous cervical spine tolerance by summing the two (also presented in data tables). This resulted in 1-1 ratio for flexion and extension at OC1 and a ratio of 1 to .76 at C7-T1. Unfortunately this could not be done for lateral bending since there was no lateral bending tolerance data.

Their analysis contained several notable limitations. Specifically:

- They assumed a maximum muscle activation strategy, which is unlikely in the real injury environment.
- All the resisting moments were calculated for the spine in the neutral position.
- No consideration was given to co-activation of contralateral muscles for stability.
- No consideration was given to passive responses on the contralateral side.
- No chin-on-chest contact was taken into account
- No muscle rate effects were considered

Their summary conclusion is that the proposed values for lateral bending are a little high. However, based on their results, and the literature, a lateral bending tolerance that is greater than the extension tolerance seems rational.

Dr. Frank A. Pintar - Medical College of Wisconsin

Dr. Frank Pintar (who was not in attendance) submitted written comments to the work group. In his comments he notes that the Technical Working Group has put forth considerable effort and that this effort represents a positive step forward in addressing the potential occupant injury risk from deploying side air bags.

In his comments he detailed cases (specific test positions) where he felt that the specified test positions were not in-fact the nominal worst-case occupant positions relative to the side air bags. He further stated that in his experience the "procedures should be such that the body region of interest - head, neck, or chest - should be in as close proximity to the air bag as possible, preferably in contact with the air bag module seam.

Specifically:

- He suggested that statements be added, such as those in position 3.3.2.2 that specifically instruct that the sternum contact the seat, in other positions to make them "worse-case".

- He also suggested the elimination of position 3.3.2.4 and 3.3.3.4 since they appear to be useless (dummy appears to be out of the path of the deploying air bag.

- Positions 3.3.2.3, 3.3.2.5, 3.3.2.6, 3.3.3.3, and 3.3.2.7 should be repositioned to bring the more vulnerable parts of the dummy closer to the path of air bag deployment or would represent a more probable seating position in the real world.

- Questioned whether having the window up in position 3.3.3.1 would maximize the air bag interaction.

- Questioned why the head-neck was always specified to be in the neutral position. He felt that it hindered the positioning to achieve "worst-case" scenarios and is not very "life-like".

Finally, he referenced his 1999 Stapp paper and suggested that the group consider those positions. He further noted that while it contained a smaller number of positions, he felt that they were more severe.

Robert Sanders – Parents for Safer Air Bags (PSAB)

Robert Sanders (who at the last minute chose not to participate on the grounds that the meeting was not open to the public/press) submitted written comments to the work group. In these written comments Mr. Sanders congratulated the group for their hard work in developing the recommended test procedures. While offering no substantive technical comment, he suggested biomechanical experts who he felt should have the opportunity to comment.

While acknowledging that it is out of the working group's scope, he requested that the working group recommend to vehicle manufacturers that they formally bind themselves to the final recommended test procedures by including the following express warranty in the vehicle owners manual.

Express Warranty

This vehicle contains side air bags. The manufacturer of this vehicle expressly warrants that the side air bags in this vehicle comply with the performance requirements contained in the "Recommended Procedures For Evaluating Occupant Injury From Deploying Air Bags" published on [date] by the Side Air Bag OOP Injury Technical Working Group Sponsored by the Alliance of Automobile Manufacturers, Association of International Automobile Manufacturers, the Automotive Occupant Restraints Counsel and the Insurance Institute for Highway Safety.

Mr. Sanders indicated that such a warranty was necessary since, without it, "vehicle manufacturers can ignore the recommended test procedures altogether, or fail them with impunity."

R. David Pittle – Senior Vice-President and Technical Director

While Consumers Union did not attend the technical review meeting (ostensibly for the same reasons as Mr. Sanders) nor submit comments to TWG on the technical draft, it did send a letter to NHTSA Deputy Administrator Rosalyn Millman regarding the TWG efforts. In that letter Consumers Union expressed concerns about the process that the agency is following to address this issue (namely allowing non-regulatory groups to develop voluntary guidelines). They also complained that consumer groups such as Public Citizen and the Center for Auto Safety were specifically denied any significant role in the development process.

While Consumers Union believes that the TWG did a comprehensive job in highlighting safety concerns with side air bags and developing methods to test them, they felt that without having direct and specific knowledge of how the TWG arrived at its decisions, they were unable to judge whether the "standard" was strong enough to protect occupants from side air bag injuries.

They also detailed several concerns about the NHTSA's potential reliance on voluntary guidelines. Specifically:

- What will be the procedures to update or change the injury criteria should they be deemed through experience to be either too forceful or not forceful enough?
- What are the rules of compliance for automakers who do not belong to the Alliance or AIAM?
- How will manufacturers who don't meet them be dealt with?
- Would the voluntary standard be a "self-certification" standard, and if so, who will have

the power to enforce the self-certification?

- Where will NHTSA derive the power to recall a vehicle that doesn't meet the voluntary standard, or will recalls simply be unavailable?

In light of the above concerns, Consumers Union asked NHTSA to launch a rulemaking on this topic and "bring the issue of side air bag safety and performance back under NHTSA's jurisdiction where it belongs".