74-14-N100-016
NHTSA-97-2705-017

TRW

ORIGINAL

September 17, 1996

10 pg

96 SEP 19

Stephen R. Kratzke
Office of Safety Performance Standards
Docket Section, Room 5109
National Highway Traffic Safety Administration
400 Seventh Street, SW
Washington, DC 20590

Dear Mr. Kratzke:

TRW applauds the aggressive manner in which NHTSA has stepped up to a difficult issue, acting as facilitator to develop and implement public education campaigns and now exploring product performance opportunities intended to avert the high priority issue of restraint induced injury. In Docket 74-14 Notice 100, NHTSA has proposed several options within §571.208 Occupant crash protection.

S4.5.1.	Very explicit, permanent labeling in the vehicle
S4.5.4.	Similar labeling with a manual passenger side airbag disable switch
S4.5.5.a	A passive (automatic) means of disabling the passenger side airbag upon determining the presence of a child seat or child whose weight is less than 30kg.
S4.5.5.b	Some other sensor or combination of sensors (undefined) which would recognize the presence of the child seat or an unbelted/improperly belted child and automatically disable the air bag.
S4.5.5.c	A system similar to the above (S4.5.5.b) but in which the passenger side air bag can be deployed in some non-injurious manner.

TRW welcomes the opportunity to provide comment on these proposed options and the specific questions raised in Notice 100. TRW has been exploring the technologies and benefits associated with "smart" enhancements to seat belt, airbag, and sensing systems for over five years and can provide credible inputs to some of the information being sought.

CA 24597

The options proposed in this notice reflect the tradeoffs encountered in trying to realize some tangible improvements in a timely manner. Dr. Martinez acknowledged that the changes viewed as affecting greatest improvement were those that required some additional time to implement and proliferate throughout the vehicle fleets. To restate the obvious, the subject options are presented in the order starting with changes that might have the least impact on vehicle design and qualification and progress out on the timeline. The questions to be answered in the responses really amount to; what are the risks, if any, with the near term solutions, what are the benefits afforded by those deemed to be longer term, and when might we expect to see them introduced into the product cycle? TRW has addressed those questions in the attached response in the order stated of the proposed wording of Section 4.5 and conclude with a recommended approach. We would be happy to discuss these comments in further detail, if desired.

Sincerely,

James L. Chamberlin
V. P. Technology Planning & Quality
TRW Occupant Restraints Systems Group

TRW Responses to Docket 74-14; Notice 100

Request for Comments regarding proposed changes to FMVSS 208

TRW views the first three options as short term solution, each with some level of benefit. Short term in the sense that similar products are in production today. In the following sections we will give our opinion as to the ability to meet the stated objectives of the NPRM as well as some assessment of potential issues that need to be addressed.

S4.5.1. Warning Labels

TRW chooses not to comment on people's ability to heed warnings and follow instructions. Clearly the proposed message is explicit and the associated timing would be immediate.

S4.5.4. Labels & Manual Disable Switches

We believe the disable switch to be the most positive means of shutting off the airbag if understood and used properly and therefore support the proposal for allowing its use in all vehicles. We share the concerns, however, expressed by a number of the commenters about people, despite instructions and telltale warning lights, remembering to use these switches in what is often an occasional circumstance. We agree strongly with the IIHS view that those who allow their children to ride unbelted in the front seat are not likely to think of turning off the airbag. For this group the switch does not satisfy the NHTSA objective of protecting the RFIS <u>and</u> the unbelted child. We also acknowledge the special needs of a portion of our population who would benefit from a manual disable switch. TRW therefore recommends continued use of the disable switches, but only until more inclusive, automatic means can be demonstrated and adopted.

S4.5.5a. Automatic Disabling of Passenger Side Airbag by Weight Sensor

The approach described in the notice suggests the placement of a switch, capable of discerning a threshold weight of something in the seat, below which the air bag would disabled. TRW views this approach as one which might meet the stated objectives but opens the door to other issues and controversy. Based only on the weight of the occupant in the seat, this approach would deprive all small children, whether or not they were normally seated, of passive/ supplemental restraint. Despite the statistics citing about 17 million cars on the road at mid-year 1996 with passenger side air bags and the 96,000 deployments of which 34% or 32,600 had someone in the passenger seat, the number of lives saved and injuries mitigated is difficult to extract from NASS and FARS data. These data focus on serious injuries and fatalities and, fortunately, these numbers are relatively small. From crash simulation testing and computer modeling, we can see that a major portion of the 32% (6,000) unbelted occupants (adult and child) in crashes severe enough to warrant an air bag deployment, would be incurring serious injuries without an air bag. Testing with 3 and 6 year old anthropomorphic dummies has shown benefit from the air bag in 14 and 30 mph tests, even with the seat in the full forward position. The complex mix of child presence in the passenger seat, child seat belt use, and the lack of real data on people saved prevent us from extrapolating to some predicted number of children that may now be lost with the turning off of the air bag. The fact that this becomes the tradeoff for the projected number of OOP children killed by deployment forces suggests a less than completely satisfactory alternative.

003

Additionally, NHTSA has suggested that the current force-sensitive resister pad which was developed to act as an occupant presence detector could be quickly redesigned to shift its switching threshold from 26 to 66 lbs and furthermore seeks concurrence with the proposed 66 lbs (30kg). TRW has considerable experience with weight sensors/switches and the sensitivity of sensor accuracy to seat design and installation parameters. We would strongly suggest, if this approach were taken as a single parameter input, that a test procedure be developed and adopted defining the position and means in which one is to measure the 66 lbs.. Furthermore, as stated in the notice, statistics support the correlation of this weight to a given age/size range of children. We would still envision considerable consternation for children just beyond the limits of whatever the selected threshold might be. This uncertainty of threshold also carries into scenarios in which a small adult might be subject to z-axis bouncing just prior to the major crash. There may well be some number of these who would have been adequately lifted as to be interpreted momentarily as a child. We can also imagine people bracing off the toe-board to access their pockets or any number of postures that would be inaccurately interpreted. Lastly, there is some concern that a leap to this approach might be viewed as negating the need for future, more inclusive versions of smart restraints technologies. With all of these uncertainties and concerns, this would not be TRW's preferred approach .

S4.5.5b Automatic Disabling of the Air Bag by Other (Multiple) Sensing Technologies

TRW believes that this approach is preferable to using just a weight/force sensor. Nevertheless, the potential consequence of disabling of an air bag by other, non-contact technologies impose tremendous reliability requirements on the data acquisition and decision criteria. These requirements may necessitate two or more sensors to reduce the ambiguity of some occupant scenarios. Occupant size and position sensors suggested in the notice, are discussed below, as discrete devices.

Occupant Size Sensing - Though not described in the notice in terms of supporting technology, this proposed approach is apparently being suggested as an alternative to the weight threshold approach. The air bag would be disabled upon the determination that the occupant of the passenger seat is below a certain threshold size. It must first be recognized that imaging technology is considerably more involved than that of weight determination. Various means of data acquisition and processing are being developed by the supplier industry and will be discussed further in the next section on ranging or position sensing. One issue we would take with size is the numerous ways in which the parameter of size can be misinterpreted. One must question the ability of an imaging system to distinguish between tall, seated people from a child standing or kneeling on the seat, a child in a bulky snow suit from a semi-reclined teenager with his knees tucked up to his chest, a small child holding a balloon, etc.. However, setting aside the issues of accuracy and reliability of the sensing task, there remain the concerns discussed in the prior section regarding the disabling of the air bag for many small children who would otherwise benefit from its restraint. TRW is not currently working on this approach and cannot comment regarding timing.

Occupant Position Sensing - This is the approach which most directly addresses the definition of "smart" as stated in the notice. Though more sophisticated than a simple force scale, the ranging or imaging technologies can provide other information beyond identifying a RFIS or an OOP child. Position sensors have been developed to specifically recognize when the seat is unoccupied or the location of the occupant, adult or child, whether still or moving towards the instrument panel. Various sensing technologies have been evaluated by TRW, the most robust of which employs the use of ultrasonics. This transmitted/received signal is outside the range of frequencies and energy that could ever present a health hazard to anyone and is least likely to be influenced or confused by the environmental conditions of the vehicle or the surface/material from which it is being reflected. The principle of function is based on sonar technology, pulsing a brief, inaudible signal, timing its return, and calculating the distance, based on the speed of sound. Early efforts in this program were conducted with both distributed and single point mountings of the sensors. Looking at the occupant compartment from a variety of positions, as in the case of a distributed system, allows an accurate "mapping" of the area of interest. Based on the individual sensors measuring specific distances to object surfaces within their respective aim, a microprocessor can compile and identify from previously programmed algorithms, what is in the passenger seat and how far they are from the instrument panel. One system under development employs several sensors mounted in a single assembly in the instrument panel, a-pillar, or wherever is most advantageous in a specific vehicle to obtain the optimal "line of sights" to the areas of interest. The single point system allows less installation and wire routing complexity but may, in some vehicles, result in some ambiguity for a few (e.g. passenger reading a newspaper) of the hundreds of occupant/position scenarios. These few confusing scenarios prompt the earlier statement that production versions will probably evolve with a second sensor, mounted remotely, to corroborate the data. This second sensor might be looking at weight as a verification of RFIS, or another sensor "'dedicated" to recognizing and tracking occupant movement. In the notice, NHTSA indicated that position sensing encounters engineering challenges when applied to the dynamics of the occupant in motion. The background on this concern stems from the fact that an unrestrained occupant may start into a crash normally seated but, due to precrash braking or slow onset types of crashes, may be just moving into close proximity to the instrument panel at the time of the firing command. Clearly, the data sampling and analysis must be accomplished in a time consistent with these potential events. The ultrasonic system has been designed based on priority inputs and time compression within close "target" proximity to adequately capture this event. We do agree with NHTSA that this concern needs to be addressed with a rigorous and repeatable test procedure. The test procedure and pass/fail criteria need to be defined to enable self-certification, as well as, directing the applications level of development testing. To our knowledge, such a procedure has not been developed to the point of formal proposal. If a coordinated effort could be initiated shortly, implementation of this approach might commence around MY 2000/1.

S4.5.5.c Any technology (or combination) which would "automatically prevent an air bag from injuring the two groups of children that experience has shown to be at special risk from air bags."

There are numerous approaches that are being explored and developed pursuant to that objective. Some, as discussed in prior Notice 97, employ traditional, design level, deployment tailoring techniques such as recessing the module, reducing the inflator slope, bag folds and tethers, etc.. Other approaches operate in real time, making adjustments to the deployment energy based upon various crash severity or occupant scenarios. Before elaborating on any of these, it is worthwhile to repeat/paraphrase the cautionary comment made by GM to Notice 97. These efforts should be pursued as directionally correct, reducing the level of risk from deployment related injuries. Given the range of susceptibility of various people to physical insult, there will always be some number of people injured by the deployment of an air bag, regardless of the extent to which it might be depowered.

The design based techniques used for reducing the risk associated with bag/occupant interaction, as stated above, were fairly well discussed in Notice 97. NHTSA has been conducting some of their own testing to evaluate the opportunities afforded by some of these techniques. While TRW supports the reduction in deployment energy in the form of reduced slope and output of the inflators, the crash pulse of today's smaller, lighter, stiffer vehicles limits the extent to which depowering can be achieved while still providing the specified performance requirements. In the majority of vehicles it will be necessary to selectively "trigger" the deployment of the bag at significantly differing energy levels. Dual-staged inflators offer the ability to meet the upper end of the performance requirements of FMVSS 208 or to deploy the bag at significantly reduced rates, when necessary. In the following section, TRW would like to suggest several approaches that are complemented by the addition of dual-staged inflators. Proposed in a somewhat ascending order of content and technical sophistication, these combination of sensing components with dual staged inflators first address the priority issues of the RFIS and OOP child but then broaden their scope to include other benefits.

Weight Sensor & Dual Stage Inflators - The force based switches, described in section 3a, causes reasons for concern if they prevent airbag deployment in all types of crashes when the seat occupant weighs less than 30 kg. On the other hand, considerable benefit can be realized in reducing the rate of bag deployment and inflation when something of less than 30 kg is in the seat. Testing and simulation analysis has indicated that an infant in the RFIS is at relatively low injury risk when the inflation rate is significantly reduced from the current FMVSS 208 performance yet the unbelted six year old child receives adequate restraint up to 30 mph. These dual stage inflators contain two separate initiators and require firing circuits back to the control module which can sequence the firing of the two stages under the defined conditions. Occupants in the seat, weighing more than the 30 kg, would allow both initiators to fire simultaneously, realizing inflation rates normal for that specific vehicle. It should be recognized that this system does not reduce the deployment energy for an adult who might be leaning or translating into a forward position. In this regard, this approach is preferred to the weight sensor/ turn off approach discussed in S4.5.5a since it does not deprive an air bag from those in need but does not address the OOP adult. The pacing item in this approach we view as the availability of the dual staged inflators. Though early versions may be released earlier, current "primary path" programs will support MY 1999 start of production.

Crash Severity Sensing, Buckle Switches, and Dual Stage Inflators - In the notice, NHTSA cited certain European systems in which weight sensors and transponder systems determine the presence of occupants and tagged infant seats. Those same manufacturers are employing buckle switches and the vehicle crash sensors to make an adjustment to the firing threshold. The logic of their approach assumes that a belted occupant does not need to be restrained as early by the airbag and they can raise the threshold to a higher delta v barrier equivalence. Based on the rapidly declining rate of auto accidents above the median 14 mph, they are able to achieve their primary objectives of fewer deployments and lower repair costs. Recognizing that all of the accidents to date, which resulted in deployment induced child fatalities, occurred at or just above the firing threhold for the air bags, TRW has been promoting an improved combination of the crash sensing and buckle switch with dual staged inflators. As presented at the '96 SAE Government & Industry Meeting in Washington, the dual stage inflator allows the decision to deploy the bags at a low inflation rate when a person is identified as being unbuckled up to some slightly higher threshold (approx. 18-20 mph) at which point they need a more aggressive deployment. The belted occupant, as with the European approach, does not need any bag at the lower, traditional threshold. In this instance, the firing of the initial stage might be raised to something like 15 mph and correspondingly, the combined, high output command at 22-24 mph. As with the prior weight sensor, this system does not attempt to identify an out-of position condition. It merely reduces the exposure rate of vehicle occupants to high output deployments. Using the normal distribution of accidents compared to crash severity, in a manner similar to that of Malliaris, et als, in their '84 SAE paper, we superimposed the threshold shifts for some hypothetical vehicle as described on the attached figure 1. Using these hypothetical thresholds, the reduced exposure or benefit of this first-generation smart system would be on the order of 79% of all passengers, normally seated and OOP. Areas (a), (b), and (d) in Fig. 1 represent the passenger populations who would benefit. For clarification, area (a) includes belted passengers (24% of all passengers) along with 33% of all RFISs who, for the ΔV crashes. below 15 mph, will not be subject to a PAB deployment. Areas (b) and (d) of Fig 1 bring in another 55% of all passengers, belted and unbelted. This includes another 50% of all RFISs, 70% of all unbelted OOP children, age 1-12, 72% of all the unbelted older children and adults and the 46% of all belted children and adults. This population, because the crash is below 22 mph for belted or 20 mph for unbelted, are provided a reduced energy deployment. TRW believes this approach, though not fully addressing 100% of the target crash populations, offers significant improvement with well understood technologies. Accelerometer based, multiple threshold descriminating sensors are in production as are self diagnosing seat belt use switches, mounted in the buckle. Additionally, the advantages beyond the objectives set forth by the Notice include the ability to reduce the deployment energy in the broader population of low severity crashes and thereby mitigating some of the more minor, abrasion type injuries experienced by normally seated and belted occupants and the severe injuries being experienced by the short female drivers. As in the prior section, the pacing element is the dual staged inflators, allowing the initial programs to use this approach for MY 1999.

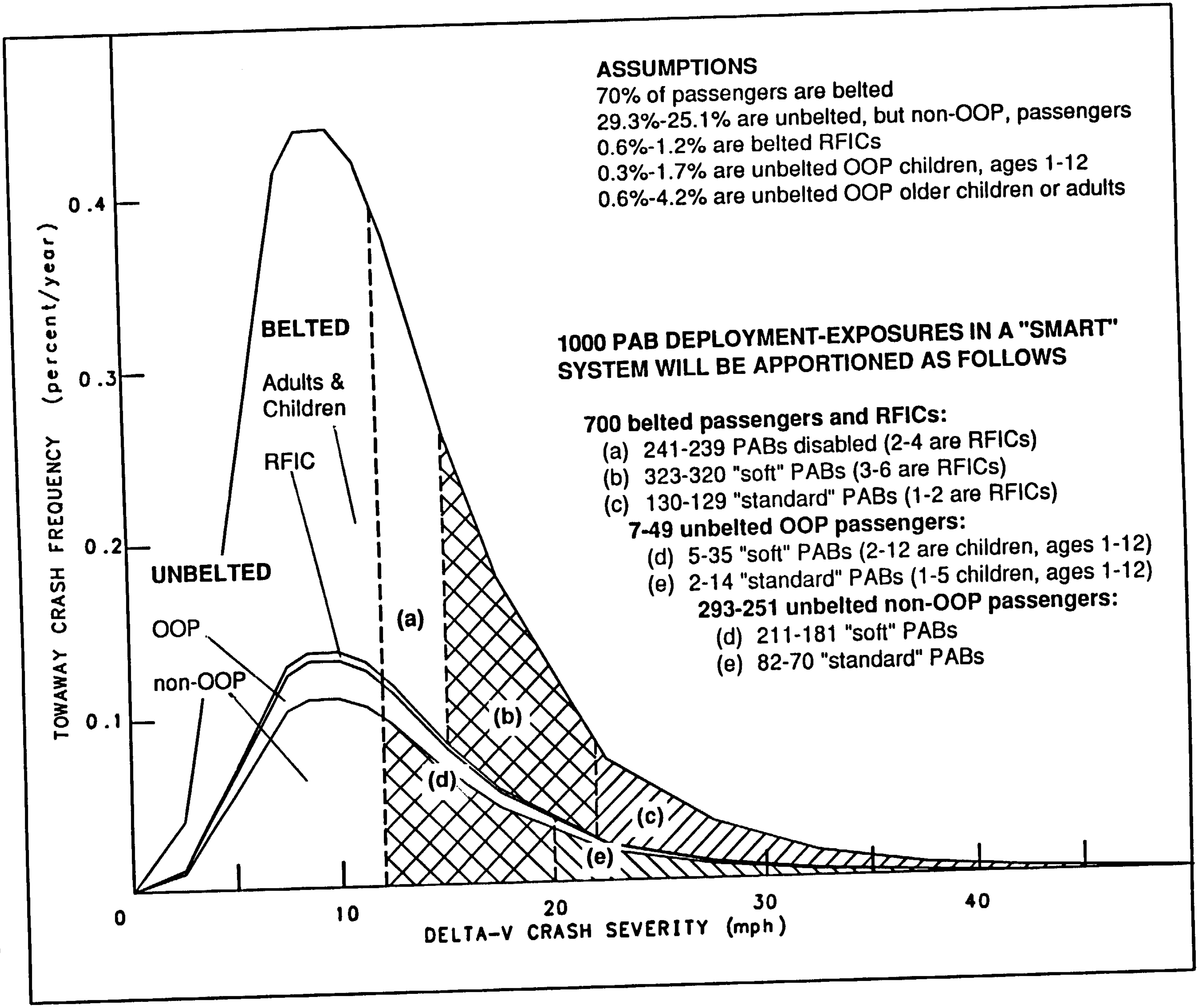
ASSUMPTIONS
70% of passengers are belted
29.3%-25.1% are unbelted, but non-OOP, passengers
0.6%-1.2% are belted RFICs
0.3%-1.7% are unbelted OOP children, ages 1-12
0.6%-4.2% are unbelted OOP older children or adults
1000 PAB DEPLOYMENT-EXPOSURES IN A "SMART" SYSTEM WILL BE APPORTIONED AS FOLLOWS
700 belted passengers and RFICs:
(a) 241-239 PABs disabled (2-4 are RFICs)
(b) 323-320 "soft" PABs (3-6 are RFICs)
(c) 130-129 "standard" PABs (1-2 are RFICs)
7-49 unbelted OOP passengers:
(d) 5-35 "soft" PABs (2-12 are children, ages 1-12)
(e) 2-14 "standard" PABs (1-5 children, ages 1-12)
293-251 unbelted non-OOP passengers:
(d) 211-181 "soft" PABs
(e) 82-70 "standard" PABs
BELTED
Adults & Children
RFIC
UNBELTED
OOP
non-OOP
(a)
(b)
(c)
(d)
(e)
TOWAWAY CRASH FREQUENCY (percent/year)
0.4
0.3
0.2
0.1
0
10
20
30
40
DELTA-V CRASH SEVERITY (mph)

Figure 1

Crash Severity Sensing, Buckle Switch, Weight Sensor (passenger), and Dual Stage Inflators - The addition of a weight sensor with a low weight threshold would be an enhancement to the system described above. Of the remaining 21% who otherwise will be subject to a high level deployment, any small children and the last 17% of the RFISs will be registered as light and buckled. Either of these two groups would benefit from a reduction in deployment energy. As described in the prior sections, the pacing item is the inflator and would allow this combination to be available for MY 99.

Crash Severity Sensing, Buckle Switch, Weight Sensor (passenger), Seat Position Switch (driver) and Dual Staged Inflators - The addition of the seat position switch which indicates when the driver seat has been purposefully taken to its forward most position provides a clear input to the system logic that the driver is very short in stature. Drivers 5' 2" and shorter tend to position their seats within 1" of the full forward position in order to comfortably reach the control pedals (internal survey). In vehicles with energy dissipating steering wheels and columns, both the belted and unbelted drivers in the full forward position, in close proximity to the steering wheel, need not be subject to the full restraint forces of a 208 level deployment. The reduced output of a dual stage could provide adequate injury mitigation approaching current compliance speeds, while reducing the risk of deployment induced injuries. The addition of the simple seat switch would not affect the above stated timing.

Position Sensing and Dual Stage Inflators - Again, dual stage inflators add another dimension of tailoring to the position sensing approach. The multi-beam ultrasonic sensing system, being developed by TRW, can recognize the difference between a RFIS and a variety of occupant conditions. Under the circumstance of a RFIS, the airbag could be disabled. Based on whether the person was at the instrument panel or at some intermediate range, the decision could be added to signal a no fire or a reduced rate. The full energy deployment can be initiated with the occupant, whatever size or weight, in the normally seated position. Again, the fundamental technologies of the ultrasonic ranging sensors and compilation of multiple inputs to develop an image have been developed and transferred from other applications. The task in question has been to demonstrate the capabilities of these technologies as we configure the systems to address the specific vehicle environments and the conditions we wish to detect. Considerable testing and analysis still needs to be done with the OEMs to assure robust production quality. As stated in S4.5.5b, this testing needs an immediate priority to support a MY 2000/1 start of production.

Crash Severity Sensing, Buckle Switch, Position Sensing, Weight Sensing, and Dual Stage Inflators - This system addresses all of the issues adjusting inflator output based on both crash severity and occupant position relative to the module.

00?

As stated at the beginning of this latter section, TRW advocates the use of systems comprised of multiple sensors and dual-staged inflators and has attempted to provide the basis for that position for each of several such system configurations. The letter of the proposed rule can be met with more simplistic approaches but we caution this action. NHTSA is pursuing stated objectives to affect a reversal in the disturbing trend of deployment induced child fatalities as quickly as possible. TRW is concerned that the objectives are too narrowly stated and may allow the introduction of systems that may result in other unforseen and unintended problems. In addressing the specific tasks of identifying and responding to the presense of the OOPO, imaging/ranging sensors are the most appropriate means but the developing of static & dynamic test procedures and criteria for self certification should not be considered trivial. This effort and the subsequent demonstration of system reliability may impose timing beyond NHTSA's intended implementation schedule. For these reasons, TRW feels the more appropriate and expeditious of the proposed approaches would be to establish an aggressive schedule whereby we continue current programs intending to launch with the manual disable switches with all their warnings, move quickly to a system employing crash severity, seat belt use, and weight to adjust the firing thresholds of two levels of deployment energy, and finally upgrade the sensing to include occupant position as the industry consenses upon a necessary test methodology.

010