U.S. Department of Transportation
1200 New Jersey Avenue SE
West Building
Washington, DC 20590–0001.

Re: Docket # NHTSA–2020–0093

Dear Administrator Cliff,

The Center for Injury Research and Prevention (CIRP) at the Children's Hospital of Philadelphia would like to commend the National Highway Traffic Safety Administration (NHTSA) for their continued focus on child passenger safety via their Notice of Proposed Rulemaking for FMVSS 213 (Docket Number: NHTSA-2020-0093). In particular, we are pleased to see an effort to improve the test bench – including the stiffness, geometry and seat belt assembly – as our previous research highlighted limitations of the previous FMVSS 213 test bench[1].

There are several other aspects of the NPRM for which CIRP research provides relevant insight. We offer the following comments to further inform NHTSA's deliberations.

1. **Denial of petition regarding a floor**

We remain disappointed that the petition to provide a floor was denied as this limits the ability of child restraint systems (CRS) to include a support leg in their design. While NHTSA did not rule out the use of a support leg, the need to have the CRS be certified without the support leg compromises and makes more complex their design. Given that the goal of FMVSS 213 is to "replicate the real world vehicle features" that "bear on a child restraint's performance", it seems appropriate that the regulation incorporate a floor as a vehicle floor is a real-world vehicle feature that can enhance the performance of CRS. Specifically, a floor and the use of a support leg for rear-facing CRS can enable accommodation of larger children rear-facing safely and more comfortably by ensuring robust load transfer and providing more space for leg room.

Our recent study[2] highlighted these benefits. Specifically, we performed sled tests to evaluate the use of a support leg in rearward-facing infant and extended-use convertible CRS models during frontal impacts. The test buck and frontal crash pulse (delta-v of 35 mph and peak acceleration of 35 g with a rise time to peak of 35 ms) were simulated from the Consumer

[1] Maltese, M.R., Tylko, S., Belwadi, A., Locey, C. and Arbogast, K.B., 2014. Comparative performance of forward-facing child restraint systems on the C/FMVSS 213 bench and vehicle seats. *Traffic injury prevention*, *15*(sup1), pp.S103-S110.

[2] Patton DA, Belwadi AN, Maheshwari J and Arbogast KB (2020) Evaluation of Rotation Reduction Features in Infant and Extended-Use Convertible Child Restraint Systems during Frontal and Rear Impacts. Stapp Car Crash Journal 64: 1-21.

Reports' protocol. The floor of the test buck was instrumented with a force plate to measure the reaction force from the support leg. The presence of a support leg in all rearward-facing CRS models used in the current study was associated with reductions in head injury metrics across a range of pediatric ATDs (aged 1 to 6 years) during frontal impacts, which was attributed to the reduction in forward rotation. Although the presence of a support leg for rearward-facing CRS did not always reduce neck injury metrics, no values exceeded injury tolerance values when the support leg was used. Average support leg reaction forces ranged from 3348 to 6401 N providing guidance as to the loads that must be tolerated by vehicle floor pans. We encourage NHTSA to reconsider this petition.

2. Communicating with today's parents and improved labelling

Continued high rates of CRS misuse highlight an important disconnect between how manufacturers instruct consumers to use their products and how caregivers' interpret or execute these instructions in real-world settings. For this reason, we commend NHTSA's consideration of alternative methods to communicate usage and recall information with today's parents. Differences in sources of information and preferences in communication across populations make it difficult to effectively communicate intended uses to all consumers. For example, our research[3] highlighted that although web-based tools and online strategies are an inexpensive and interactive way to provide use instructions to many families, only 15% of Black caregivers actually use online resources to learn about CRS compared with 54% of White caregivers. This study also found that compared with highly educated caregivers, caregivers with less formal education are more likely to seek out instructions from primary care physicians, family members, and friends. These findings suggest that our communication strategies must be broad and diverse.

Further, the population that manufacturers must communicate with has drastically shifted in recent decades. In 2014, 6% of all US households included a grandchild living with a grandparent, and ~2.7 million of these grandparents served as a primary caregiver for the child, a 7% increase from 2009 (US Census Bureau). This increase was in part attributed to the 2008 economic recession, and there is speculation that this number will substantially increase again as a result of economic impacts of the COVID-19 pandemic (Pew Research Center). It is also likely that the needs of this growing group of caregivers may differ from the general, historical population of CRS users, as 33% of grandparents who are primary caregivers do not hold a high school degree (US Census Bureau).

Therefore, we support NHTSA's proposals to expand the number of options in which consumers can register their CRS, as well as the ways in which manufacturers are allowed to communicate important CRS information (both in the importance of registering seats and communicating weight/height limits printed on seats). With more options available, manufacturers may be

[3] Mirman JH, Seifert SJ, Metzger KB, Durbin DR, Arbogast KB, Zonfrillo MR. (2017). Caregivers' use of child passenger safety resources and quality of future child restraint system installations. *Safety*. *3*(4):24.

enabled to effectively engage with and communicate their guidance to a wider audience. In addition, options to communicate with caregivers that are not tied to physical address (e.g. electronic means of communication) may lead to enhanced dissemination of messages to caregivers that rent their place of residence and may move often. That said, we also believe that NHTSA should consider new ways to standardize some CRS communications, such as mandating that all materials be written at very low (3rd-5th grade) reading levels. CIRP, along with our colleagues at the Ohio State University Injury Biomechanics Research Lab, have ongoing research to characterize where and how caregivers of different backgrounds obtain and would prefer to obtain information about CRS, what informs these preferences, and if these sources of information influence knowledge and use of CRS technologies and installation methods. There is a particular focus on older and racial/ethnic minority caregivers. We would welcome the opportunity to share our findings with NHTSA when complete, likely in 2022.

4. Increasing lower weight limit for belt-positioning booster seats to 40 lbs.

NHTSA proposes to increase the lower weight recommendation for belt-positioning booster seats from 30 to 40 lbs. A recent study[4] led by a CIRP researcher supports these efforts. Specifically, we compared child (aged 4-8 years) behaviors during simulated vehicle trips while restrained in either a forward-facing harness or a belt-positioning booster seat. This study analyzed the amount of time children spent in a sub-optimal position (e.g., leaning out of the seat), and found that children who were restrained in the forward-facing harness did not spend any time in sub-optimal or unsafe positions. Conversely, 4-year-olds restrained in belt-positioning boosters spent on average 70% of the vehicle trip inappropriately seated (compared with 5-, 6-, 7-, and 8-year-olds all spending on average less than 30% of the trip in an unsafe position). Thus, this study concluded that younger children may be physically compatible with booster seats from an anthropometric perspective, but not mature enough to use them appropriately. These findings highlight the importance of delaying the transition from a harnessed seat to a booster seat. Therefore, following NHTSA's justification that current percentiles for weight in the United States list that 30 lbs (~13.6 kg) is the 50th percentile of weight for boys aged 2.6 years and for girls aged 2.9 years, we support their proposal to increase the lower weight recommendation for belt-positioning booster seats from 30 to 40lbs.

However, we also need to remember that a booster seat is better than a seat belt for this age/weight range. We always need to be careful about unintended consequences of the message– we do not want families to interpret messaging to mean booster seats are unsafe for those 30-40 lbs and put their young children in seat belts or worse allow them to go unrestrained.

5. Child Passenger Safety Issues Arising from Research Findings

Regarding novel designs of booster seats (e.g. inflatable designs, heightless designs), it is important to recognize that the primary role of the booster seat is to adapt the vehicle seating

[4] Sartin, E., McDonald, C. C., Long, D. L., Stavrinos, D., & Mirman, J. H. (2020). Variations in booster seat use by child characteristics. *Journal of Safety Research*, *74*, 89-95.

geometry and restraints, that were designed for adults, to the child. This is intended to account for both anthropometry and biomechanical differences between children and adults. While the lab results presented in the supplemental materials of the NPRM raise concerns about the performance of some of these novel designs, it is important to consider the behavioral aspects as well – a feature unable to be assessed via ATDs in sled/crash tests. Specifically, the boost provided by the structure of the traditional booster seats is needed for seat belt fit reasons but also to avoid slouching, allowing children to bend their legs over the front edge of the booster. Our research using the PIPER pediatric human body model illustrates important differences in kinematics between optimally positioned occupants and those positioned in more naturalistic and realistic postures[5,6]. It is important to assess using pediatric human volunteers how these novel designs influence child posture and not limit assessment only to ATD evaluation in sled/crash tests.

Preliminary work examining the performance of heightless booster seats revealed important differences between static belt fit and dynamic belt performance. Heightless booster seats route the belt away from the soft abdomen and the neck similar to traditional booster seats but do so without the "boost" in an effort to reduce the size and mass and increase the convenience of the restraint. Both sled tests and computational modeling using the PIPER human body model demonstrated delayed contact between the lap belt and the pelvis due to the fact that the lap belt is positioned far forward on the thighs[7]. Using kinematic rather than kinetic metrics to assess submarining such as change in torso angle (defined as angle made by shoulder to hip to knee), this research identified differences between these novel designs and traditional booster seats that may indicate a potential for suboptimal kinematics that current ATDs and FMVSS213 test modes may not be able to reproduce. Future research should further develop evaluation metrics that can accurately predict how real children sustain injuries – using advanced technology such as computational human body models to generate an environment where innovation is encouraged but unintended consequences are avoided.

Lastly, we encourage NHTSA to further develop side impact test methods for CRS. This crash mode is important to study and accelerating regulation in this area is critically needed. Specifically, we suggest that NHTSA consider side impact protection for booster seats different from harness-based CRS as protection in these two types of CRS are managed differently. As discussed above, booster seats raise the child and allow them to be protected by the safety components of the vehicle that have been put there to protect adults. In frontal crashes, this is

[5] Maheshwari J, Sarfare S, Falciani C, Belwadi A. Analysis of Kinematic Response of Pediatric Occupants Seated in Naturalistic Positions in Simulated Frontal Small Offset Impacts: With and Without Automatic Emergency Braking. Stapp Car Crash J. 2020 Nov;64:31-59. PMID: 3363600

[6] Maheshwari J, Sarfare S, Falciani C, Belwadi A. Pediatric occupant human body model kinematic and kinetic response variation to changes in seating posture in simulated frontal impacts - with and without automatic emergency braking. Traffic Inj Prev. 2020 Oct 23:1-5. doi: 10.1080/15389588.2020.1825699. Epub ahead of print. PMID: 33095067.

[7] Belwadi et al, "Efficiency of booster seat design on the response of the Q6 ATD in stimulated frontal sled impacts" Protection of Children in Cars Conference, Munich, Germany, 2017

primarily the benefit of the adult seat belt. In side crashes, this includes side curtain airbags and other energy management features of vehicle interiors. Any side impact regulations for boosters could/should look different from the currently proposed protocol for harnessed seats where the protection needs to be provided by the child restraint itself. Boosters serve a different purpose than harnessed CRS – so we encourage NHTSA to consider compliance standards that can be different as well.

In summary, we commend NHTSA for continuing to evolve regulations for child restraints. We encourage that these efforts should not only consider advancements to laboratory test methods but also evaluations of usability across diverse user groups. Improving the tools and assessment metrics in a direction that more closely mimics the real-world experience for children on our roads in vitally important.

Thank you for the opportunity to provide feedback on the NPRM. Our mission at CIRP is to improve the safety of children, youth and young adults on our roads and we value sharing our research findings with key stakeholders like NHTSA in order to advance our mission.

Respectfully submitted,

Kristy Arbogast, PhD
Co-Scientific Director, Center for Injury Research and Prevention
Co-Director, Center for Child Injury Prevention Studies
Co-Director, Minds Matter Concussion Program
R. Anderson Pew Distinguished Chair and Professor, Department of Pediatrics
University of Pennsylvania Perelman School of Medicine

representing the CIRP research team of Valentina Graci PhD, Jalaj Maheshwari MS, Declan Patton PhD, and Emma Sartin Goodman PhD.