INTERIM REPORT TO CONGRESS

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Section 24221(a) of the Bipartisan Infrastructure Law mandated a GAO study to evaluate the availability and use of crash test dummies. Section 24221(b) of the BIL also directed the Administrator of the U.S. Department of Transportation's National Highway Traffic Safety Administration to transmit to Congress an interim report that identifies (1) the types of crash test dummies used by the NHTSA in the Federal Motor Vehicle Safety Standards and the New Car Assessment Program, (2) how each type of test dummy is tested with respect to seating position, and (3) any crash test dummies that the Administration is actively evaluating for future use in the FMVSS or NCAP.

Crash Test Dummies

INTERIM REPORT TO CONGRESS ON CRASH TEST DUMMIES

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Executive Summary

Section 24221(a) of the Bipartisan Infrastructure Law (BIL) mandated a GAO study to evaluate the availability and use of crash test dummies. Section 24221(b) of the BIL also directed the Administrator of the U.S. Department of Transportation's (DOT) National Highway Traffic Safety Administration (NHTSA) to transmit to Congress an interim report that identifies (1) the types of crash test dummies used by the NHTSA in the Federal Motor Vehicle Safety Standards (FMVSS) and the New Car Assessment Program (NCAP), (2) how each type of test dummy is tested with respect to seating position, and (3) any crash test dummies that the Administration is actively evaluating for future use in the FMVSS or NCAP. Appendix A contains the full statutory language.

Safety is the top priority for the DOT and NHTSA and equity in safety outcomes is central to our mission across all categories of drivers. NHTSA's use of crash test dummies dates to the 1970s, when the first dummy was codified into the FMVSS 49 CFR Part 572. Since that time, NHTSA has regulated numerous other dummies that range in age, size, and sex, from children, to small females, to midsize males. NHTSA recently released a report examining sex disparities in crash fatalities resulting from similar physical impacts.[1] The recent study contains encouraging findings on reductions in fatality risk disparities in newer model year vehicles. The overall difference in fatality risk between male and female occupants dropped from 18.3 percent for model year 1960-2009 vehicles to 2.9 percent for model year 2015-2020 vehicles. While this reduction is noteworthy, any remaining disparity is unacceptable, and NHTSA is committed to eliminating it through effective approaches. Crash dummies will be a vital tool in that effort.

Use of an expanded array of crash test dummies in NHTSA's crash tests has helped to reduce crash fatalities. This report provides an overview of the current crash test dummies used in NCAP as well as in compliance testing under the FMVSS, and those being developed and evaluated for future use. In addition, pursuant to § 24221(b), this report describes the Administration's plans for implementing these dummies and the associated challenges and recommendations. Finally, this report discusses the ways in which we develop and use various computer simulation tools in our research to bolster our crash test program as a supplement to physical crash tests.

Introduction

The FMVSS identify mandatory minimum safety performance requirements for motor vehicles and certain motor vehicle equipment in the United States. Vehicles and equipment manufactured for sale in the United States must be certified to comply with all applicable FMVSS. In addition to FMVSS compliance, NCAP is a consumer information program that evaluates vehicle safety beyond the mandatory requirements. At times, a single crash test can be used to inform both FMVSS and NCAP assessments. Critical elements of both FMVSS and NCAP testing are crash test dummies, which are used to assess human injury potential in a crash.

NHTSA's use of crash test dummies dates to the 1970s, when the first dummy was codified into NHTSA's regulation for Anthropomorphic Test Devices (ATD)[2], 49 CFR Part 572. Since that time, as the FMVSS and

[1] Noh, E. Y., Atwood, J. R. E., Lee, E., Craig, M. J., (2022) Female crash fatality risk relative to rales for similar physical impacts (Report No. DOT HS 813 358). Washington, DC: National Highway Traffic Safety Administration.

[2] The technical term for a crash test dummy is 'Anthropomorphic Test Device.'

NCAP have evolved, NHTSA has codified numerous other dummies that range in size, age, and measurement capability, ranging from midsize adult males to small adult females to infants, toddlers, and older children. In addition, NHTSA has continually conducted research into advancements in crash safety, including the development of advanced dummies that better represent the interaction of vehicle occupants with modern restraint systems, such as force-limited three-point seat belts and air bags.

Current Crash Test Dummies

Regulated crash test dummies are documented in 49 CFR Part 572; 'Anthropomorphic Test Devices.' Motor vehicles and motor vehicle equipment are tested for compliance with the FMVSS using these crash test dummies. The design and performance criteria specified in 49 CFR Part 572 are intended to describe measuring tools with sufficient precision to give repeatable and correlative results under similar test conditions. Additionally, the criteria specified ensure the dummies adequately evaluate the protective performance of a vehicle or item of motor vehicle equipment with respect to human occupants in a reproducible manner. The same criteria will be applied to all dummies under development prior to their use in testing. The current crash test dummies, their respective test conditions, and their seating positions are comprehensively tabulated in Appendix B and summarized herein. Figures of select full-vehicle FMVSS and NCAP tests are further provided in Appendix C. NHTSA tests the female test dummies in the same seating positions as male dummies where occupant body type has a bearing on crash outcome. The dummies used in crash tests are selected to address safety concerns identified in field and test data accounting for occupant demographics, occupant seating positions, and crash direction and speed.

Adult Female

The **Hybrid III 5th Percentile Adult Female Frontal Crash Test Dummy** (HIII-05F) was introduced into 49 CFR Part 572, Subpart O in 2000. The HIII-05F represents a small adult female and has a seated height of 78.7 cm (31.0 in) and weight of 49.1 kg (108.0 lbs). Current test modes where the HIII-05F is specified for use include FMVSS No. 208 "Occupant Crash Protection" and frontal impact in NCAP. As part of FMVSS No. 208, the HIII-05F is utilized in belted and unbelted conditions for the driver and right front passenger seating positions. Three FMVSS 208 dynamic frontal crash tests are conducted with the HIII-05F: 1) two belted dummies in a vehicle that impacts a full-width rigid barrier at an impact angle of 0 ± 5° at a speed of 56 km/h; 2) two unbelted dummies in a vehicle that impacts a full-width rigid barrier at an impact angle of 0 ± 5° at a speed of 32-40 km/h; and 3) two belted dummies in a vehicle that impacts a deformable barrier that is offset from the center of the vehicle by 40% at an impact speed of 40 km/h and at an impact angle of 0°. In addition, consistent with FMVSS No. 208, the HIII-05F is used in out-of-position static air bag deployment tests. The frontal NCAP test is similar to the first FMVSS No. 208 test condition, except that the impact angle is 0° and the dummy is in the right front passenger seat position only.

The **Side Impact Dummy (SID)-IIs 5th Percentile Adult Female Side Crash Test Dummy** (SID-IIs) was introduced into 49 CFR Part 572, Subpart V in 2006. The SID-IIs represents a small adult female and has a seated height of 79.0 cm (31.1 in) and weight of 44.5 kg (98.1 lbs). Current test modes where the SID-IIs is specified for use include FMVSS No. 214 "Side Impact Protection" and side impact in NCAP. This dummy is tested in two FMVSS 214 conditions: 1) moving deformable barrier impacting a vehicle at 27° at 53 km/h (32.9 mph) (SID-IIs is in the struck-side rear passenger seat); and 2) vehicle impacting a 254 mm (10 in) diameter rigid pole at an angle of 75° at 0-32 km/h (0-20 mph) (the SID-IIs is in the struck-side driver's seating position or in the struck-side right front seating position). The side moving deformable barrier NCAP test condition is the same as the first FMVSS No. 214 test condition but conducted at an elevated speed of 62 km/h (38.5 mph). In the side pole NCAP test condition, the physical test configuration is the same as in FMVSS No. 214. Also, in the NCAP tests, the SID-IIs is utilized in belted out-of-position conditions.

Adult Male

The **Hybrid III 50th Percentile Adult Male Frontal Crash Test Dummy** (HIII-50M) was introduced into 49 CFR Part 572, Subpart E in 1986. The HIII-50M represents a mid-sized adult male and has a seated height of 88.4 cm (34.8 in) and weight of 77.7 kg (171.0 lbs). Current test modes where the HIII-50M is specified for use include FMVSS No. 208 "Occupant Crash Protection" and frontal impact in NCAP. As part of FMVSS No. 208, the HIII-50M is utilized in the driver and right front passenger seating positions for two full-width frontal crash tests of a vehicle into a rigid barrier: 1) belted, 0° at 56 km/h (34.8 mph); and 2) unbelted, 0° ± 30° at 32-40 km/h (20-25 mph). The first test condition with the HIII-50M in the driver position also serves as the frontal NCAP test. The HIII-50M is also used in FMVSS 202a 'Head Restraints' for head restraint assessment.

The **EuroSID-2 with Rib Extensions 50th Percentile Adult Male Side Crash Test Dummy** (ES2re) was introduced into 49 CFR Part 572, Subpart U in 2006. The ES2re represents a mid-sized adult male and has a seated height of 90.9 cm (35.8 in) and weight of 72.0 kg (159.0 lbs). Current test modes where the ES2re is specified for use include FMVSS No. 214 "Side Impact Protection" and side impact in NCAP. The ES2re is belted and utilized in the driver or right front passenger seating positions in these side impact tests so that the dummy is always seated on the impacted side. This dummy is tested in two FMVSS 214 conditions: 1) moving deformable barrier impacting a vehicle at 27° at 53 km/h (32.9 mph); and 2) vehicle impacting a 254 mm (10 in) diameter rigid pole at an angle of 75° at 0-32 km/h (0-20 mph). The side NCAP condition is the same as the first FMVSS No. 214 test condition but conducted at an elevated speed of 62 km/h (38.5 mph).

Child

The **Civil Aeromedical Institute Newborn Infant Crash Test Dummy** (CAMI) was introduced into 49 CFR Part 572, Subpart K in 1993. Developed by the Civil Aeromedical Institute, this canvas-covered dummy represents a newborn infant and has a weight of 3.4 kg (7.5 lbs). As a representation of an infant, the CAMI has no representative "seated height." The CAMI is used in FMVSS No. 213 "Child Restraint Systems" in addition to more recent advanced dummies, such as the CRABI. The CAMI is also referenced in FMVSS No. 208 for testing of car beds.

The **Child Restraint Air Bag Interaction (CRABI) 12-Month-Old Child Crash Test Dummy** (CRABI) was introduced into 49 CFR Part 572, Subpart R in 2000. This dummy represents a 12-month-old child and has a seated height of 47.0 cm (18.5 in) and weight of 10.0 kg (22.0 lbs). The CRABI is used to evaluate air bag exposure to infants restrained in child safety seats that are placed in the front seat as specified in FMVSS No. 208, as well as air bag suppression testing. In total, there are 23 unique test conditions specified in FMVSS No. 208 using the CRABI. FMVSS No. 213 and FMVSS No. 213a also specify use of the CRABI to test child safety seat frontal and side crash protection.

The **Hybrid III 3-Year-Old Child Crash Test Dummy** (HIII-3YO) was introduced into 49 CFR Part 572, Subpart P in 2000. This dummy represents a 3-year-old child and has a seated height of 54.6 cm (21.5 in) and weight of 16.2 kg (35.7 lbs). The HIII-3YO is specified for use in FMVSS No. 208 for out-of-position and suppression testing, where two unique test configurations are specified. The HIII-3YO is also specified for use in FMVSS No. 213, as well as for out-of-position test conditions in NCAP.

The **Q3s 3-Year-Old Child Side Crash Test Dummy** (Q3s) has recently been finalized by NHTSA, with a final rule issued in November 2020 (49 CFR Part 572, Subpart W). This dummy represents a 3-year-old child and has a seated height of 55.6 cm (21.9 in) and weight of 14.5 kg (32.0 lbs). NHTSA issued a final rule in June 2022 incorporating the Q3s ATD into FMVSS No. 213a "Child Restraint Systems – Side Impact Protection."

The **Hybrid III 6-Year-Old Child Crash Test Dummy** (HIII-6YO) was introduced into 49 CFR Part 572, Subpart N in 2000. This dummy represents a 6-year-old child and has a seated height of 63.5 cm (25.0 in) and weight of 23.4 kg (51.6 lbs). The HIII-6YO is specified for use in FMVSS No. 208 for out-of-position and suppression testing, where two unique test configurations are specified. The HIII-6YO is also specified for use in FMVSS No. 213, as well as for out-of-position test conditions in the side NCAP.

The **Hybrid III Weighted 6-Year-Old Child Crash Test Dummy** (HIII-6YO-W) was introduced into 49 CFR Part 572, Subpart S in 2004. This dummy represents a larger 6-year-old child and has a seated height of 63.5 cm (25.0 in) and weight of 23.4 kg (51.6 lbs). The HIII-6YO-W is specified for use in FMVSS No. 213 to test child seats.

The **Hybrid III 10-Year-Old Child Crash Test Dummy** (HIII-10YO) was introduced into 49 CFR Part 572, Subpart T in 2012. This dummy represents a 10-year-old child and has a seated height of 72.4 cm (28.5 in) and weight of 35.3 kg (77.6 lbs). The HIII-10YO is suited to test the upper load and height limits of safety restraints and is used in FMVSS No. 213 to test belt-positioning booster seats.

Crash Test Dummies Under Development

Adult Female

The **Test Device for Human Occupant Restraint (THOR) 5th Percentile Adult Female Frontal Crash Test Dummy** (THOR-05F) is currently being developed and evaluated by NHTSA. NHTSA has accelerated the development of the THOR-05F in this Administration. The THOR-05F represents a small adult female and has a seated height of 81.3 cm (32.0 in), approximate standing height of 151 cm (59.4 in), and weight of 49 kg (108.0 lbs). NHTSA has incorporated improved designs resulting from the development of THOR-50M related to the head, neck, thorax and lower extremities into the design of the THOR-05F. Additionally, the THOR-05F has other improved measurement capabilities over the HIII-05F, including face loads, clavicle loads, thorax displacement, abdominal pressure, acetabulum loads, and ankle displacements and loads. These measurements will permit evaluation of injury types not currently considered. THOR-05F may be used in in FMVSS No. 208 and NCAP frontal crash test conditions.

Currently, NHTSA is evaluating the THOR-05F's biofidelity and durability, developing design updates to improve durability, developing injury criteria, and developing documentation in coordination with the manufacturer. The standardization of the THOR 5th (RIN: 2127-AM56) is expected to start in 2023.

The **World Side Impact Dummy (WorldSID) 5th Percentile Adult Female Side Crash Test Dummy** (WorldSID-05F) is currently under development. The WorldSID-05F represents a small adult female and has a seated height of 76.1 cm (30.0 in), approximate standing height of 151 cm (59.4 in), and weight of 48 kg (105.8 lbs). The WorldSID-05F incorporates all of the improved measurement capabilities and internal data acquisition systems of the WorldSID-50M. Possible test modes in which the WorldSID-05F may be used include FMVSS No. 214 and NCAP side impact testing.

Current NHTSA activities include evaluating the WorldSID-05F's biofidelity, evaluating new thoracic injury prediction instrumentation, and developing documentation. Completion of documentation is expected in 2025 to support a rulemaking decision.

Adult Male

The **THOR 50th Percentile Adult Male Frontal Crash Test Dummy** (THOR-50M) is currently being finalized by NHTSA for proposed inclusion in Part 572 and for use in FMVSS No. 208 as an optional test device. The THOR-50M represents a mid-sized adult male and has a seated height of 94 cm (37 in), an approximate standing height of 175 cm (68.9 in), and a weight of 76 kg (167.6 lbs). In comparison to the HIII-50M, the THOR-50M provides improved biofidelity (i.e., a measure of the dummy's ability to mimic a human-like response in a crash) in the thorax, shoulder, spine, knee-thigh-hip, lower leg and abdomen, as well as improved kinematic response to a frontal crash. Additionally, the THOR-50M allows for multi-point deflection measurements in the thorax and abdomen, upper and lower tibia load cells, and acetabulum load cells, all of which allow for measurement of new injury criteria.

NHTSA has active rulemakings concerning both the standardization of the THOR-50M (RIN: 2127-AM20) and allowing for optional use of the THOR-50M in place of the HIII-50M in FMVSS No. 208 (RIN: 2127-AM21). In addition to FMVSS No. 208 testing, possible uses for the THOR-50M include frontal NCAP tests.

The **WorldSID 50th Percentile Adult Male Side Crash Test Dummy** (WorldSID-50M) is currently being finalized by NHTSA for proposed inclusion in Part 572 and for use in FMVSS No. 214 as an optional test device. The WorldSID-50M represents a mid-sized adult male and has a seated height of 87 cm (34.3 in), an approximate standing height of 175 cm (68.9 in), and a weight of 74 kg (163.1 lbs). The WorldSID-50M offers improved lateral and oblique biofidelity in the thorax when compared to the ES-2re, improved biofidelity in the abdomen and pelvis, as well as the utilization of on-board data acquisition systems and multi-point deflection measurement in the thorax.

NHTSA is currently planning to publish a 49 CFR Part 572 NPRM in the Winter of 2022 (RIN: 2127-AM22), and plans to publish an NPRM for optional use of the WorldSID-50M in place of the ES-2re in FMVSS No. 214 at the same time (RIN: 2127-AM23). In addition to FMVSS No. 214 testing, possible uses for the WorldSID-50M include side NCAP tests. Finally, the WorldSID-50M is being evaluated for use in far-side test modes.

The **Biofidelic Rear Impact Dummy** (BioRID) is currently under development. The BioRID was initially developed in Europe and NHTSA is evaluating its potential use in the U.S. The BioRID represents a mid-sized adult male and has a seated height of 88 cm (34.6 in), an approximate standing height of 168 cm (66.1 in), and a weight of 78 kg (172.0). BioRID is the first dummy to have a continuous, articulated spine that can be instrumented in such a way that allows for the measurement of intervertebral rotations of the cervical spine. Hence, these measurements provide improved assessment of whiplash injury when compared to the HIII-50M.

NHTSA is evaluating the BioRID's biofidelity, developing injury criteria, and developing documentation. Potential applications of the BioRID include testing for FMVSS No. 202a "Head Restraints" and/or FMVSS No. 207 "Seating Systems." Completion of documentation is anticipated in 2024 to support a rulemaking decision.

Child

The **Large Omnidirectional Child (LODC) 10-year-old Child Crash Test Dummy** (LODC) is currently under development by NHTSA. The LODC represents a 10-year-old child and has a seated height of 68 cm (26.8 in), approximate standing height of 130 cm (51.2 in), weight of 34.6 kg (76.3 lbs), and is designed to represent both male and female children. The LODC offers a flexible thoracic spine resulting in more accurate head motion, a biofidelic abdomen with pressure sensors for instrumentation. Also, the LODC incorporates biofidelity characteristics derived directly from pediatric biomechanical data, includes omnidirectional instrumentation, and represents improved anthropometry of a 10-year-old child in comparison to the HIII-10YO.

Currently, NHTSA is completing testing and documentation development. The LODC is intended for use in FMVSS No. 213 and rear seat positions with or without a booster seat. Other possible test modes include FMVSS No. 208 and NCAP testing. Completion of documentation is expected in 2023 to support a rulemaking decision.

Challenges for Crash Test Dummy Implementation

Safety is NHTSA's top priority, and the agency is committed to developing advanced crash test dummies that enable a more comprehensive assessment of injury mechanisms and safety features in new model year vehicles. A crash test dummy on its own needs to be applied in a relevant crash test program with appropriate performance measures to be effective at promoting the development of safety countermeasures that reduce injuries and fatalities resulting from motor vehicle crashes. NHTSA takes great efforts to ensure that dummies are effective representations of motor vehicle occupants and have a human-like response, or are "biofidelic," in a crash. To this end, crash test dummy development is a complex and lengthy process requiring a cooperative approach between NHTSA and dummy manufacturers, involving numerous design iterations aimed at refining accuracy and precision to best reflect actual human kinematics and resulting injury measures in a crash. An assessment of a dummy's biofidelity includes, but is not limited to, anthropometry, mass properties, joint properties (e.g., range of motion), and response to crash forces.

Biofidelity must be weighed against other requirements, including durability, repeatability, and reproducibility of the dummy motion and injury prediction. Biofidelity and durability are often competing priorities. Developing a dummy that not only has a human-like response but also remains intact through multiple crashes is a considerable challenge and necessitates the previously mentioned iterative design process with manufacturers.

It is sometimes difficult to establish age, gender, and/or size specific injury criteria for different dummies in part due to the availability of test data from post-mortem human subjects with desired characteristics. In the past, this has often meant that injury criteria were scaled from one dummy size to another (e.g., 50th male to 5th female). Currently, NHTSA is attempting to collect additional age, size, and gender appropriate data for describing response and injury measures for different adult dummies.

Use of Computer Simulation to Supplement Physical Crash Tests

NHTSA has long supported the development of computer simulation models of humans, crash test dummies, and vehicles. These state-of-the-art tools can be used in studying injuries and injury causation as well as developing more advanced vehicle structures and restraint systems. It is not feasible to run an actual crash test to answer every research question related to occupant safety. The overarching benefit of computer simulations is that they offer a fast, efficient, and comprehensive method to supplement safety research.

Computer simulation models (including finite element, lumped parameter, and machine learning) are commonly used among the vehicle safety community as part of vehicle design and crash safety assessment. Models of vehicles and their safety systems facilitate the evaluation and development of vehicle countermeasures (e.g., structures, air bags, seat belts) for an expanded range of simulated crash conditions, such as varying severities, impact directions, crash durations, etc. Further, occupant demographics such as age, gender, size, seating position, seating orientation, and posture can be considered in computer models. These modeling tools allow for research to expand out to other human demographics beyond the typical 5th percentile female and 50th percentile male used in crash tests (e.g., obese, elderly, etc.). Once adequately validated for their specific purpose, these vehicle and human models are often used together to analyze the effects of changing safety system designs and crash parameters on injury outcomes for varying occupant demographics.

While industry and researchers also use simulation models extensively, establishing standards and criteria for specific simulation tools to be used and accepted by all users for vehicle safety assessments presents challenges. There are many important considerations associated with these simulation techniques. Primarily, such models need to be validated in real-world or standardized, representative crash test conditions. How to validate these models more broadly for conditions that extend beyond performed physical test conditions also needs to be considered. Further, procedures for validating and qualifying simulation models would need to be standardized. Consistency of results would need to be evaluated and other computing considerations standardized. Finally, in a regulatory framework, NHTSA must ascertain the compliance of vehicles as they are produced in the real world, not as idealized computer models that may not represent the design and manufacturing process accurately.

Plans for Future Research

People can have different risks of injury in a crash. NHTSA's Annual Modal Research Plan[3] outlines the research topics the Agency pursues, including those targeted to better understand and effectively address gender equity in crash safety outcomes. NHTSA is further developing a research plan that details several tracks to address the remaining disparities in crashworthiness safety testing and outcomes. These research efforts are specifically focused on female occupant crash safety, spanning field data analysis, tool development and demonstration application. In addition, as described above, human body modeling research efforts are underway to consider occupants and vulnerable road users of all ages, shapes, and sizes.

Previous NHTSA work has studied the fatality and injury risks for females and males. While males are overrepresented in overall fatalities, it is generally known that the overall risk-taking difference between males and females is a major confounding factor. To account for this, in a study by the agency[4], NHTSA controlled for this dominant factor by focusing on comparable front-end crashes with similar

[3] RD&T Annual Modal Research Plans

[4] Kahane, C. J., (2013). Injury vulnerability and effectiveness of occupant protection technologies for older occupants and women. (Report No. DOT HS 811 766). Washington, DC: National Highway Traffic Safety Administration.

characteristics only, which found that females had an overall 17.0% and 28.8% increased fatality and nonfatal-injury risk, respectively, relative to males, when looking at all historical fatal crashes involving all vehicle model years dating back to the 1960s. While this study and its finding control for the dominant risk-taking difference, the result is very heavily dominated by crashes involving vehicles that pre-date generations of crashworthiness improvements introduced into newer vehicles. Therefore, the overall finding in the 2013 report does not reflect fatality and nonfatal-injury risk differences in modern vehicles. The majority (78%) of vehicles used in the 2013 study were not equipped with the latest generations of seat belts and air bags, and many were designed before NHTSA adopted the use of 5th percentile adult female test dummies in FMVSS crash testing. As such, the 17.0% and 28.8% increased fatality and nonfatal-injury risk, respectively, of females relative to males does not reflect the crash protection safety performance of today's vehicles.

To better understand the differences in risk for females versus males in crashes in newer model year vehicles, NHTSA recently updated the fatality risk results of the 2013 study to include the latest crash data, which includes substantially more vehicles equipped with seat belts, dual advanced air bags, and other countermeasures designed for a greater diversity of occupants. The update found that the relative risk of fatality between females and males has been reduced, especially when considering newer vehicles[5]. The increase in fatality risk for females relative to males for model year 2010-2020 vehicles was found to be 6.3 ± 5.4% and is significantly less than for model year 1960-2009 vehicles (18.3 ± 1.2%). For model year 2015-2020 vehicles, the estimated difference in fatality risk between females and males appears further reduced to 2.9 ± 9.8% percent for the average of drivers and right-front passengers; however, due to data scarcity, this statistic will need further observation. In addition to comparing model year ranges, the study also assessed relative fatality risk for different generations of occupant protection systems. For the latest generation of systems (dual air bags, seat belt pretensioners and load limiters), the estimated increase in female fatality risk relative to males was 5.8 ± 3.8%, which is statistically significantly lower than for belted occupants in vehicles without those occupant protections (21.0 ± 3.5%). A 2015 NHTSA study[6] demonstrated that three-point belts and air bags were equally effective in reducing fatalities for both males and females.

NHTSA is also using the largest and newest crash database systems, such as the National Automotive Sampling System-Crashworthiness Data System (NASS-CDS) and the Crash Injury Sampling System (CISS) to describe injury odds ratios for females versus males given a comprehensive set of crash, restraint, and occupant-related factors. Understanding the relative risk difference in crashes involving modern vehicles is relevant; design changes to modern vehicles must address female crash safety differences identified in the current vehicle fleet.

To better predict and prevent fatalities and injuries for female occupants involved in motor vehicle crashes, NHTSA has focused on developing tools such as advanced crash test dummies that are more human-like than current dummies. NHTSA is working with the dummy manufacturer to improve the durability of the advanced female dummies so they can be more robust and utilized in the many seating positions NHTSA seeks to assess for occupant crash protection.

[5] Noh, E. Y., Atwood, J. R. E., Lee, E., Craig, M. J., (2022) Female crash fatality risk relative to rales for similar physical impacts (Report No. DOT HS 813 358). Washington, DC: National Highway Traffic Safety Administration.
[6] Kahane, C. J., (2015). Lives saved by vehicle safety technologies and associated Federal Motor Vehicle Safety Standards, 1960 to 2012 – Passenger cars and LTVs – With reviews of 26 FMVSS and the effectiveness of their associated safety technologies in reducing fatalities, injuries, and crashes. (Report No. DOT HS 812 069). Washington, DC: National Highway Traffic Safety Administration.

In addition to being more biofidelic, the advanced crash dummies have improved instrumentation and sensing capabilities. For example, one important finding of our ongoing field data analysis is that women experience a higher rate of lower limb injuries than men. Current Hybrid III dummies do not have any ankle sensors that quantify loads during a crash, whereas advanced dummies such as the THOR-50M and THOR-05F are capable of measuring forces, moments, and angles in the ankle. NHTSA has recently accelerated the development of this measurement capability in the THOR dummies. While ankle injury criteria do not exist for the advanced dummies yet, NHTSA is working to collect the necessary data through postmortem human subjects (PMHS) testing. The combination of defining lower leg injury criteria and implementing these advanced dummies into testing programs will drive new vehicle countermeasures to reduce lower extremity injuries that will benefit all occupants. In the development of advanced female crash test dummies, NHTSA makes use of all available female-specific data for design, response, and injury criteria. Where female-specific data are not available, NHTSA has plans to collect those data through human subject and crash test dummy testing programs.

NHTSA plans to continue to support the development of computer models to aid in the improvement of crash safety. Specifically, NHTSA supports the Global Human Body Models Consortium's (GHBMC) development of finite element human body models (HBMs) and their use to study causes of injury, as described above. NHTSA is also using HBMs to assess possible benefits of developing new physical crash dummies (e.g., a female crash test dummy that is 50th percentile in size).

After the development and refinement of advanced dummies and human body models, NHTSA plans to conduct fleet testing to assess how the advanced dummies interact with vehicle systems. These main research areas (field data, tool development and demonstration application) are aimed at understanding where disparities exist in crash outcomes and how to better predict and prevent fatality and injury for all occupants involved in motor vehicle crashes. In addition, this research will support agency decisions regarding possible future updates to regulation and/or NCAP.

Recommendations and Conclusion

Despite the demonstrable improvements observed in crash outcomes in newer model years, any disparity in safety outcomes is unacceptable. NHTSA has long focused on developing advanced crash test dummies that are more human-like than current dummies and that have improved instrumentation and sensing capabilities. NHTSA recommends continuing field data statistical analyses to better understand current differences in fatality and injury risk based on demographic characteristics, including sex Any identified differences can then inform the direction of dummy technology and HBM development. NHTSA recommends continued research on fleet testing and countermeasure studies to understand how vehicle safety systems can be optimized for safety based on demographic needs.

As required by Section 24221(b) of the BIL, this report documents crash test dummies currently used in the NCAP and testing relating to FMVSS and crash test dummies being actively developed and evaluated for future use. NHTSA has adopted numerous dummies that range in size and age, from child to small female to midsize male. NHTSA has continually conducted research into injury tolerance, advancements in crash safety and advanced dummies that better represent the interaction of vehicle occupants with modern restraint systems.

In addition, NHTSA has long supported the development of computer models of humans. Computer simulation has the potential to be used to supplement physical crash tests; however, many challenges with this approach still exist. Finally, the Administration is executing comprehensive research plans to address disparities in crashworthiness safety testing. NHTSA will continue to focus on identifying where disparities exist in crash outcomes and how to better predict and prevent fatalities and injuries for all occupants involved in motor vehicle crashes.

Appendix A – Statutory Language

SEC. 24221. GAO REPORT ON CRASH DUMMIES.

(a) IN GENERAL.—Not later than 1 year after the date of enactment of this Act, the Comptroller General of the United States shall conduct a study and submit to the Committee on Commerce, Science, and Transportation of the Senate and the Committee on Energy and Commerce of the House of Representatives a report that—

(1) examines—

(A) the processes used by the National Highway Traffic Safety Administration (referred to in this section as the ‘‘Administration’’) for studying and deploying crash test dummies;

(B)(i) the types of crash test dummies used by the Administration as of the date of enactment of this Act;

(ii) the seating positions in which those crash test dummies are tested; and

(iii) whether the seating position affects disparities in motor vehicle safety outcomes based on demographic characteristics, including sex, and, if so, how the seating position affects those disparities;

(C) the biofidelic crash test dummies that are available in the global and domestic marketplace that reflect the physical and demographic characteristics of the driving public in the United States, including—

(i) females;

(ii) the elderly;

(iii) young adults;

(iv) children; and

(v) individuals of differing body weights;

(D) how the Administration determines whether to study and deploy new biofidelic crash test dummies, including the biofidelic crash test dummies examined under subparagraph (C), and the timelines by which the Administration conducts the work of making those determinations and studying and deploying new biofidelic crash test dummies;

(E) challenges the Administration faces in studying and deploying new crash test dummies; and

(F) how the practices of the Administration with respect to crash test dummies compare to other programs that test vehicles and report results to the public, including the European New Car Assessment Programme;

(2) evaluates potential improvements to the processes described in paragraph (1) that could reduce disparities in motor vehicle safety outcomes based on demographic characteristics, including sex;

(3) analyzes the potential use of computer simulation techniques, as a supplement to physical crash tests, to conduct virtual simulations of vehicle crash tests in order to evaluate predicted motor vehicle safety outcomes based on the different physical and demographic characteristics of motor vehicle occupants; and

(4) includes, as applicable, any assessments or recommendations relating to crash test dummies that are relevant to reducing disparities in motor vehicle safety outcomes based on demographic characteristics, including sex.

(b) INTERIM REPORT FROM THE ADMINISTRATION.—Not later than 90 days after the date of enactment of this Act, the Administrator of the Administration shall submit to the Committee on Commerce, Science, and Transportation of the Senate and the Committee on Energy and Commerce of the House of Representatives a report that—

(1) identifies—

(A) the types of crash test dummies used by the Administration as of the date of enactment of this Act with respect to—

(i) the New Car Assessment Program of the Administration; and

(ii) testing relating to Federal Motor Vehicle Safety Standards;

(B) how each type of crash test dummy identified under subparagraph (A) is tested with respect to seating position; and

(C) any crash test dummies that the Administration is actively evaluating for future use—

(i) in the New Car Assessment Program of the Administration; or

(ii) for testing relating to Federal Motor Vehicle Safety Standards;

(2) explains—

(A) the plans of the Administration, including the expected timelines, for putting any crash test dummies identified under paragraph (1)(C) to use as described in that paragraph;

(B) any challenges to putting those crash test dummies to use; and

(C) the potential use of computer simulation techniques, as a supplement to physical crash tests, to conduct virtual simulations of vehicle crash tests in order to evaluate predicted motor vehicle safety outcomes based on the different physical and demographic characteristics of motor vehicle occupants; and

(3) provides policy recommendations for reducing disparities in motor vehicle safety testing and outcomes based on demographic characteristics, including sex.

Appendix B – Current Crash Test Dummies

Table 1. Characteristics of current crash test dummies defined in 49 CFR Part 572.

Crash Test Dummy	Defined In	Simulated Sex	Seated Height	Weight
Hybrid III 50th Percentile Adult Male (HIII-50M)	49 CFR Part 572, Subpart E	Male	88.4 cm (34.8 in)	77.7 kg (171 lb)
ES-2re 50th Percentile Adult Male (ES2re)	49 CFR Part 572, Subpart U	Male	90.9 cm (35.8 in)	72.0 kg (159 lb)
Hybrid III 5th Percentile Adult Female (HIII-05F)	49 CFR Part 572, Subpart O	Female	78.7 cm (31 in)	49.1 kg (108 lb)
SID-IIs Small Adult Female (SID-IIs)	49 CFR Part 572, Subpart V	Female	79.0 cm (31.1 in)	44.5 kg (98.1 lb)
Civil Aeromedical Institute Newborn Infant (CAMI)	49 CFR Part 572, Subpart K	N/A*	N/A	3.4 kg (7.5 lbs)
CRABI 12-month-old child (CRABI)	49 CFR Part 572, Subpart R	N/A*	47 cm (18.5 in)	10 kg (22 lb)
Hybrid III 3-year-old child (HIII-3YO)	49 CFR Part 572, Subpart P	N/A*	54.6 cm (21.5 in)	16.2 kg (35.7 lb)
Q3s 3-year-old child (Q3s)	49 CFR Part 572, Subpart W	N/A*	55.6 cm (21.9 in)	14.5 kg (32 lb)
Hybrid III 6-year-old child (HIII-6YO)	49 CFR Part 572, Subpart N	N/A*	63.5 cm (25 in)	23.4 kg (51.6 lb)
Hybrid III Weighted 6-Year-Old Child (HIII-6YO-W)	49 CFR Part 572, Subpart S	N/A*	63.5 cm (25 in)	27.9 kg (61.6 lbs)
Hybrid III 10-year-old child (HIII-10YO)	49 CFR Part 572, Subpart T	N/A*	72.4 cm (28.5 in)	35.3 kg (77.6 lb)

*Child dummies are designed to represent both female and male children.

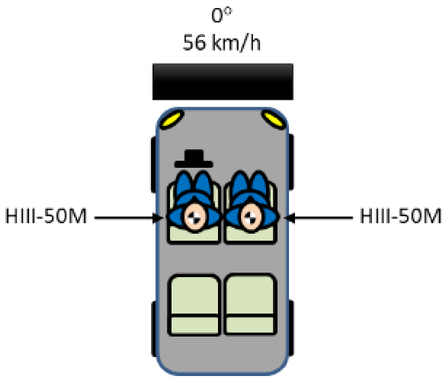
Table 2. Test conditions and seating positions of current crash test dummies defined in 49 CFR Part 572. Figures of select full-vehicle FMVSS and NCAP tests are provided in Appendix C.

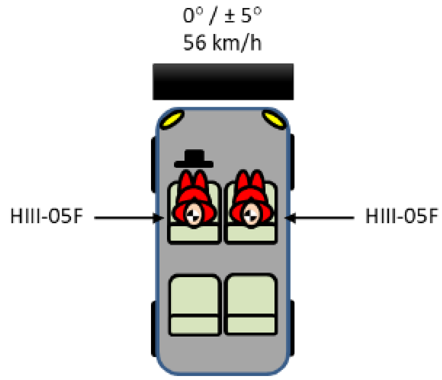
Appendix C – Figures of Select Full-Vehicle Crash Tests

Figures are not to scale.

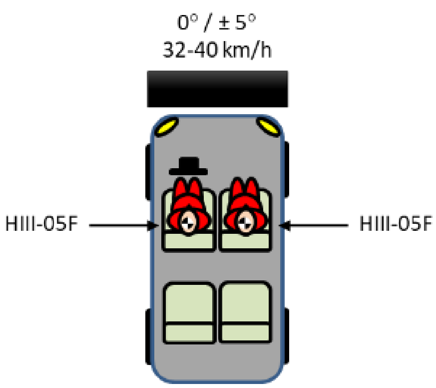
FMVSS 208, Full Width Frontal

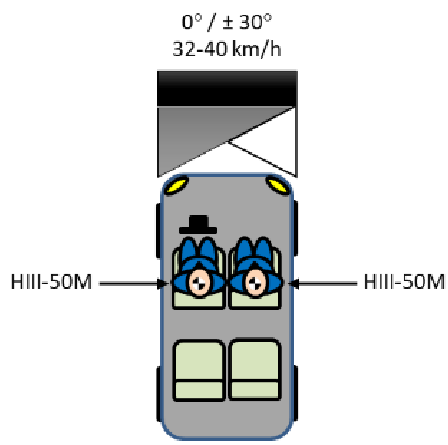
<u>Belted</u>





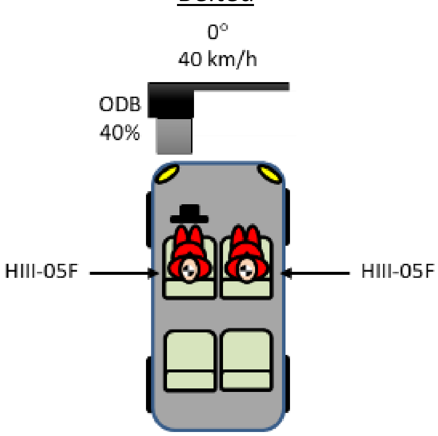
<u>Unbelted</u>





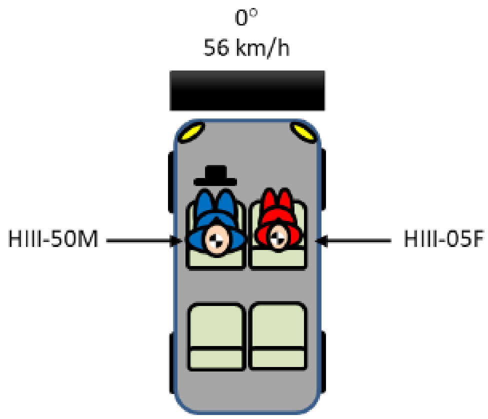
FMVSS 208, Offset Frontal

<u>Belted</u>



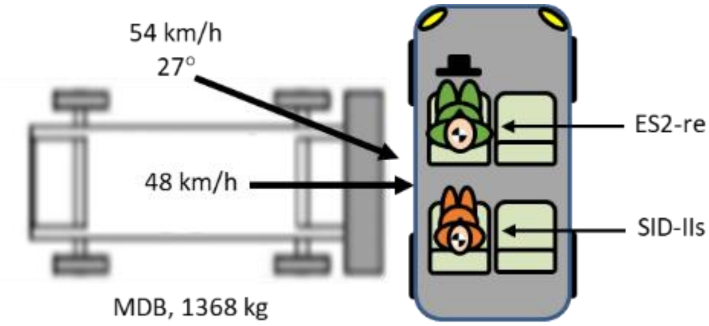
NCAP, Frontal

Belted



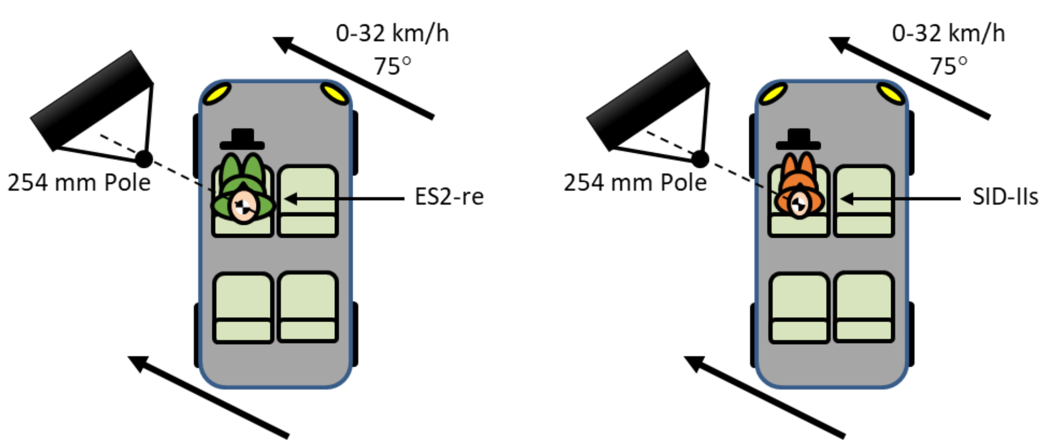
FMVSS 214, Side Barrier (Exemplar Left-Side Test)

Belted



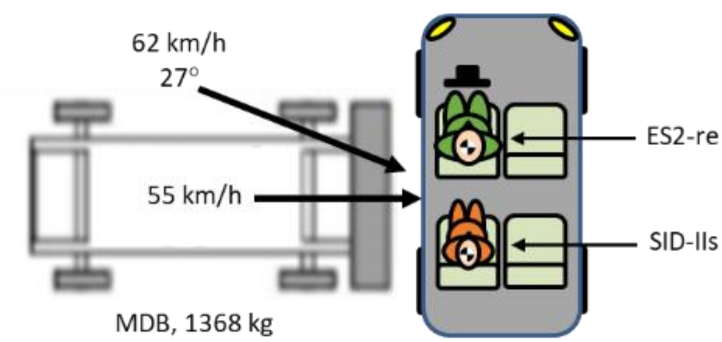
FMVSS 214, Side Pole (Exemplar Left-Side Test)

Belted



NCAP, Side Barrier

Belted



NCAP, Side Pole

Belted