United States Department of Transportation
Annual Modal Research Plan FY 2022
Program Outlook FY 2023

National Highway Traffic Safety Administration
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Executive Summary

Introduction

The National Highway Traffic Safety Administration (NHTSA) was established by the Highway Safety Act of 1970, as the successor to the National Highway Safety Bureau, to carry out safety programs under the National Traffic and Motor Vehicle Safety Act of 1966 and the Highway Safety Act of 1966. NHTSA works every day to help Americans drive, ride, and walk safely. The Agency does this by promoting vehicle safety innovations, identifying vehicle safety defects, setting safety standards for cars, trucks, buses, and motorcycles, establishing guidance, and educating Americans to help them make safer choices. Throughout its more than 50-year history, NHTSA has remained grounded in data, scientific research, and sound engineering to fulfill its mission to save lives, prevent injuries, and reduce economic costs due to road traffic crashes. Research is a critical component that performs a wide array of studies, producing scientific findings and data that inform the Agency's safety programs and allows identification of countermeasures that have led to hundreds of thousands of lives saved on our Nation's roadways throughout its existence.[1] Increasingly, and reflected in this fiscal year (FY) 2022 AMRP, research efforts are mindful of the need to address the increasing numbers of vulnerable road user fatalities, the need to focus on diversity considerations in our research studies (e.g., gender, racial equity, etc.), and meet the needs of underserved populations more broadly in our programs.

NHTSA contains two main safety research offices: The Office of Vehicle Safety Research (VSR) and the Office of Behavioral Safety Research (BSR).[2] NHTSA's research programs support the United States Department of Transportation's (USDOT's) goals of safety, transportation equity, climate change, transformational investment, as well as the Agency's safety mission to save lives, prevent injuries and reduce economic costs due to road traffic crashes, through education, research, safety standards and enforcement activity. NHTSA accomplishes its mission by continuously assessing alternative approaches and technologies that could expedite life-saving improvements in vehicles. As new vehicle designs and technologies are under development and introduced into the market, the VSR research program evaluates whether they would enhance safety. Likewise, when a potential real-world safety need is identified for a new Federal motor vehicle safety standard (FMVSS), NHTSA conducts research to understand the safety need in detail, develops and/or evaluates safety countermeasures, and establishes objective, repeatable, and reproducible performance tests that aim to address the safety need.

NHTSA also continuously reviews all ongoing research projects and examines the pandemic's effects on the ability to perform research. Specifically, for projects involving researcher interactions with human subjects, delays may result from research organizations' Institutional

[1] http://www-nrd.nhtsa.dot.gov/Pubs/812069.pdf

[2] BSR is within NHTSA's Office of Research and Program Development.

Review Boards amending protocols to protect participants and staff from additional health/safety risks. To accommodate these delays, NHTSA is exploring all appropriate measures, including no-cost time extensions to research contracts and refinements to data collection protocols.

VSR and BSR Research Activities

VSR and BSR share the mission to provide national leadership in planning, implementing, and communicating research programs to continually further NHTSA's goals in the reduction of crashes, fatalities, and injuries. NHTSA's research targets all motor vehicle classes, including heavy and light trucks, light passenger vehicles, buses, multi-purpose passenger vehicles, low-speed vehicles, and motorcycles, as well as alternative fuels vehicle platforms (e.g., electric vehicles).

Consistent with the USDOT's strategic goals, NHTSA's FY 2022 research plans prioritize vulnerable road user safety, including pedestrians, bicyclists, and persons with disabilities. Equity considerations are also an important priority in our research planning, including considerations for representative test tools including crash test dummies and the composition of research focus groups. The broad scope of research activities under VSR supports USDOT safety goals, which include researching all levels of emerging technology, as well as conventional safety systems including: driver controls, tires, lighting, and occupant and nonoccupant (e.g., pedestrian) crash protection systems. The Agency's work spans the full crash timeline, including crash avoidance, crash energy mitigation and injury reduction, and post-crash safety. NHTSA conducts crash data analyses, monitors market trends, evaluates countermeasures, develops test procedures, and engages in extensive stakeholder outreach and feedback to identify priority safety areas and potential emerging safety risks and opportunities related to motor vehicles and motor vehicle equipment.

VSR's Vehicle Research and Test Center (VRTC), located in East Liberty, Ohio, conducts applied research in support of NHTSA and USDOT programs and goals to reduce crashes, fatalities, and injuries on the nation's roadways. This is accomplished by supporting the Agency's policy decisions and regulatory agenda, safety defect investigations, developing performance test metrics and methods for existing and new vehicle technologies, providing quick engineering assessments of urgent concerns, such as newly reported cyber vulnerabilities, and conducting other applied research.

In FY 2022, major VSR research areas will focus around: vehicle electronics and cybersecurity, Automated Driving Systems (ADS) (SAE International (SAE) driving automation Levels 3-5);[3] Advanced Safety Technologies (SAE driving automation Levels 0-2 Advanced Driver

[3] These are systems still under testing and development, and at maturity, would perform the full driving task without an attentive human driver.

Assistance Systems (ADAS) and heavy vehicle technologies);[4] human injury mechanisms; crashworthiness research to improve crash survivability; and alternative fuel safety.

FY 2022 research will focus on a variety of areas pertaining to ADAS systems' performance characterization that have potential to reduce light and heavy vehicle crashes with other vehicles, as well as injuries and fatalities involving vulnerable road users such as pedestrians, pedal-cyclists, and motorcyclists. ADAS efforts will involve exploring critical studies to understand human interactions with vehicle technologies, identify accessibility considerations, conduct system performance studies, and conduct test track research to develop test procedures and performance criteria. Research will also support functional safety of vehicle electronics, investigate new methods and tools to assess vehicle cybersecurity, address ADS research needs by researching ADS safety assessment methods and metrics as well as developing tools and simulation models to support ADS alternative seating design safety.

Crashworthiness research will, further, include enhancing occupant protection for current and future vehicle designs, crash testing to support Agency regulatory efforts, crash test dummy development and testing, studies to quantify and address female injury risk, and safety considerations for alternative fuel technologies. Funding will also allow NHTSA to enhance and expand its testing capabilities for electric vehicles and vehicles equipped with advanced technologies at VRTC.

For FY 2023, VSR's major research areas will continue with increased emphasis on electrification, transportation equity considerations in the development of research projects (e.g., safety evaluation studies, focus groups, test procedures and crash test dummies) and vulnerable road user safety. New projects will continue to address open safety research questions, emerging trends, and support the execution of Agency priorities.

Behavioral research provides an evidence-based foundation for State and community traffic safety programs. One objective of BSR is to improve State-based safety programs carried out under the Highway Safety Grant (23 U.S.C. 402) and the National Priority Safety Grant (23 U.S.C. 405) programs. The research program is designed to find effective ways to influence the behavior of drivers and other roadway users to increase safe behavior (seat belt use, child seat use, protective gear use by motorcycle riders, etc.), as well as reduce unsafe behavior (alcohol- and drug-impaired driving, texting, speeding, etc.) that are critical to prevent motor vehicle crashes, deaths, and injuries.

BSR focuses on unsafe driving behaviors that contribute significantly to death and injury from crashes on the Nation's roadways, thus supporting Department and Agency safety goals. BSR

[4] These represent systems most available to consumers today and support the drivers but require their full and continuous attention to remain engaged in the driving task.

assesses existing and emerging highway safety problems and conducts evaluation research to document the relative effectiveness of programs to reduce motor vehicle fatalities and injuries. Results are distributed to the States to use in identifying effective traffic safety countermeasures for implementation under various grant programs.

In FY 2022, BSR plans to focus on four priority areas: preventing alcohol- and drug-impaired driving, improving pedestrian safety, preventing distracted driving, and improving novice driver safety. Planned projects to improve pedestrian and novice driver safety will address human factors issues related to ADAS and ADS technologies. BSR will also continue to collaborate with VSR's Automated Driving Systems and Advanced Safety Technologies research programs to address human factor issues including behavioral adaptation and child-specific safety considerations related to vehicle technologies. Examples of these issues include the use of child restraint systems in shared mobility situations and human factors concerns involving unattended children in ADS-equipped vehicles.

Likewise, BSR will further its efforts to identify more effective and efficient countermeasures for existing traffic risks such as speeding, nonuse of seat belts, nonuse and misuse of child restraint systems, and to develop new solutions for emerging and resurgent problems.

In FY 2023, BSR will decide on several emphasis areas based upon problem identification and research needs, although continued efforts are expected in preventing drug-impaired driving and addressing the effects of new technologies on behavioral safety. In these emphasis areas, BSR plans to conduct foundational research to understand the nature or scope of the problem, developmental research that helps refine the delivery of solutions, and a hybrid that combines research into big ideas and potential ways to develop those ideas into safety programs.

Collaboration Efforts

NHTSA's VSR programs primarily produce technical reports, data, information, and tools for use by the Agency, motor vehicle equipment suppliers, motor vehicle manufacturers, the technology industry, test facility operators, test equipment developers, academia, consumer organizations, State and local governments, and other Federal government agencies. With electrification and driving automation at the forefront of the automotive industry, battery and technology companies have become increasingly prominent stakeholders. The role of safety on top of the technical complexities of vehicle integration may present unfamiliar challenges for some of the new entrants.

NHTSA works closely with stakeholders in academia, which use the Agency's information to conduct complementary research or develop new materials, test methods, or test devices. Consumer organizations incorporate the Agency's research into their own programs in order to deliver safety messages, improve information to the public, and incorporate NHTSA research outcomes into strong strategic programs. State and local governments may use information to

make decisions, such as whether or how to allow for testing of vehicles equipped with ADS on their roadways.

VSR products are also used within NHTSA to support continued efforts in rulemaking and consumer information programs, to support data-driven policy decisions, to deliver equitable safety benefits to the public, and in effective safety program development. They are similarly used within other agencies for supporting research and implementing policies, practices, and standards development.

VSR activities often result in the development of test procedures, test devices and injury criteria used industry-wide for crash testing, as well as standardized performance tests and technology evaluations that either lead to improved safety and performance or provide the means to further encourage promising safety advancements. VSR research activities have also resulted in voluntary guidance and best practices for industry to utilize, as well as research to inform Agency policy decisions for nascent innovation and futuristic technological safety advancements.

BSR primarily produces information and programs for use by States, communities, and nongovernmental organizations that have a direct role in implementing traffic safety programs. It provides information to these users on emerging highway safety problems and effective and promising traffic safety countermeasures for implementation through the Highway Safety Grant (23 U.S.C. 402) and National Priority Safety Grant (23 U.S.C. 405) programs. BSR has contributed significantly to the widespread adoption of numerous programs proven to reduce crashes. Examples include the national Click It or Ticket (CIOT) high-visibility enforcement program, the adoption of Standardized Field Sobriety Tests (SFST) by law enforcement officers investigating impaired driving cases, enactment of primary seat belt and distracted-driving laws, the national .08 Blood Alcohol Concentration (BAC) limit, advancement of Graduated Driver Licensing (GDL) laws, greater understanding of older-driver issues, and development and testing of effective pedestrian and bicyclist safety programs.

BSR's research often results in the development of training programs for use by a variety of state and local governments and nongovernmental safety organizations. One example is the Drug Recognition Expert (DRE) program for identifying drug-impaired drivers now in use by law enforcement agencies in every State and pedestrian and bicyclist crash typing in use by many state and local governments. Another example is the child safety seat inspection station program developed by BSR, which is currently managed by Safe Kids International. BSR staff are expected to remain active participants in the Department's Human Factors Research Working Group. They will continue sharing their research results as well as learning about new literature and methodologies to inform new and existing projects.

NHTSA also partners with other USDOT modal agencies, such as the Federal Highway Administration (FHWA), the Federal Motor Carrier Safety Administration (FMCSA), and the Federal Transit Administration (FTA), on research activities that have multimodal applications. NHTSA makes use of the Office of the Secretary's (OST) Highly Automated Systems Safety Center of Excellence (HASS COE) and various Topical Research Working Groups as relevant and highlighted throughout this document to assist with coordination across the Department, including those specifically focused on implementing the Administration's Executive Orders. Additionally, to ensure no research duplication occurs with known prior or current projects within the USDOT, NHTSA cooperates with OST's Research Review Working Group, which reviews Agencies' Annual Modal Research Plans (AMRPs) and project spend plans. Other specific collaboration efforts are detailed under individual program areas.

NHTSA has reviewed all ongoing research to determine the effects of the pandemic on the ability to perform research. For projects with researcher interactions with human subjects, there are delays as research organizations' Institutional Review Boards amend protocols to protect participants and staff from additional risks. To accommodate these delays, NHTSA is exploring all appropriate measures, including no-cost time extensions to research contracts and refinements to data collection protocols. NHTSA is also closely monitoring proposed practices for protection of human subjects that are under development at the Departmental level and will implement any new process when it is finalized.

NHTSA's mission and research programs are primarily safety-related and are not economic growth programs. The Agency does not require or issue transportation project permits. As NHTSA has always done, when evaluating new automotive technologies, it will be guided by its statutory mission, the laws it enforces, and the safety benefits of the technology.

Evaluation and Performance Measurement

Performance measures are set for each specific project and are reviewed throughout the lifecycle of the project. NHTSA's research offices work with the Agency's Offices of Government Affairs and Strategic Planning and Budget to set performance goals and indicators that align with the Government Performance and Results Modernization Act of 2010 (GPRA Modernization Act). These are living documents that are updated annually, and targets are usually set for the next 3-5 years and revisited and revised as necessary based on performance data and trends, with documentation to explain any changes. These are then reflected in all Agency planning and reporting documents (e.g., budget submissions, strategic and performance plans, etc.). Longer term (5-10 years) performance measures are usually set as Department/Agency visionary goals.

The Agency also actively participates in the Departmental Evaluation/Performance Measurement Working group to monitor and evaluate the contribution of research, development and technology activities toward the achievement of USDOT strategic goals and objectives, such as

equity and climate solutions. Likewise, its Data Working Group ensures access to high-quality data to support data-driven technologies, operations, and decision making.

When new vehicle safety countermeasures are developed by the Agency through regulation, NHTSA's National Center for Statistics and Analysis (NCSA) typically does a retrospective review of Agency regulatory actions after implementation to determine the real world effectiveness in reducing injuries/fatalities due to motor vehicle crashes, which are part of USDOT's and NHTSA's short- and long-term performance metrics. These have traditionally been national-level assessments of the programs.

Similarly, for traffic safety countermeasures, NHTSA continuously monitors whether States and communities adopt programs it has identified as successful and through program evaluations further reviews the programs to verify that safety increases are achieved. These program evaluations, as well as evaluations conducted by others, inform the effectiveness ratings in *Countermeasures That Work: A Highway Safety Countermeasure Guide for State Highway Safety Offices*. *Countermeasures That Work* is a basic reference guide to assist State Highway Safety offices in selecting effective, evidence-based, behavioral strategies for traffic safety problem areas. Likewise, the Agency continually monitors traffic safety for emerging issues, including seeking input from NHTSA regional offices, State highway safety offices, nongovernmental stakeholder organizations, and Transportation Research Board (TRB) standing committees. This information is used by the Agency to develop new programs or to modify current programs and practices to increase efficiency and effectiveness, as well as to address emerging trends.

Additionally, in assessing behavioral changes, including seat belt use, correct child safety seat use, speeding, hand-held cell phone use, and other changes, the Agency often conducts observations to measure behaviors before and after program implementation. In other cases, the Agency measures the change in the number of crashes that occur after a program is implemented. On a routine basis, OST also meets with each modal administration to review its progress toward meeting performance targets and indicators under its internal Performance Management Review process. The Agency uses this channel to discuss trends that may impact meeting strategic goals and planned approaches. NHTSA completes near-term estimates for the effectiveness of new programs in reducing injuries and fatalities for the associated crash/road user types. Long-term, NHTSA also completes retrospective regulatory analyses to evaluate the actual effectiveness of programs (generally about 10 years after introduction to allow for fleet penetration and for the collection of sufficient field data to support analysis).

NHTSA's research programs are participating in new evaluations that are underway across the Department, including equity assessments in our programs, policies, guidelines, and activities.

NHTSA is aware that equal is not the same as equitable and although the goal of safety is to provide equal protection for all individuals inside and outside of the vehicle, the Agency is assessing potential changes in that delivery and means by which to reform programs. One particular example for VSR is the efforts into gathering data to assess female crash safety and performing essential research to determine if the Agency has done enough to protect humans of varying sizes.

The work conducted under NHTSA's research programs support USDOT's and NHTSA's top priority and performance goal of safety, while also considering the Departmental priorities of equity for all road users, climate solutions, economic growth and transformation. At the Departmental level, surface transportation safety is measured through its annual overall outcome performance measures of reducing the fatality rates of passenger vehicle occupants, non-occupants (pedestrians and bicyclists), motorcycle riders, and large truck and bus occupants. NHTSA tracks and reports on these outcome measures through data collected by the NCSA. NHTSA's research offices do not individually track such performance measures. Tracking and reporting are conducted in coordination with OST.

Likewise, NHTSA's contract research includes specific deliverables and dates that must be met for the successful performance of the research task. These deliverable items are carefully monitored, and contractor performance is recorded in the Contractor Performance Assessment Reporting System (CPARS). Project long-term goals align with all Departmental and Agency Strategic Planning and Performance Management initiatives under the GPRA Modernization Act toward achievement of NHTSA's mission. NHTSA reviews and updates its goals annually.

Technology Transfer (T2)/Deployment Activities

Technology Transfer (T2) refers to handing off and sharing research information and results to stakeholders. Outcomes from VSR's research include publicly accessible information that allows external stakeholders to perform test procedures, manufacture test devices, and develop evaluation tools. BSR works to develop sound data by which to develop and verify countermeasures to affect or change driver behaviors and provide local communities with information and tools to initiate and administer safety programs.

NHTSA research outcomes are often in the form of written documentation of research results and packages of materials designed for public consumption rather than tangible devices or materials intended for market. T2 and deployment activities are focused on opportunities and methods for providing materials in public forums: document databases (National Transportation Library (NTL) and USDOT Research Hub), internet (NHTSA website, Github), NHTSA public meetings, NHTSA rulemaking dockets, national conferences (e.g., Lifesavers, SAE International Government/Industry), international conferences (International Technical Conference on the

Enhanced Safety of Vehicles (ESV)), journal publications, public speaking engagements, and presentations.

For BSR, all recent projects are listed in the USDOT Research Hub as imported from the TRB Research in Progress (RiP) database. Records are updated at the end of each fiscal year to reflect new reports, including new contracts awards and modifications. As research projects produce deliverables, reports and other materials approved by the Agency are provided to the NTL Digital Library to be added to the Behavioral Safety Research collection, and links to the documents are added to the Research Hub record.

VSR also provides published reports directly to the NTL Digital Library and adds to the Vehicle Safety Research web page through coordination with NHTSA's Office of Communication and Consumer Information. Documents published to the NTL must meet a level of accessibility stipulated across the Federal Government. Additional research products from VSR are available in the Docket for public viewing, and NHTSA has updated materials on the Crash Simulation Vehicle Models page of the NHTSA website to assist industry in assessment of vehicle crash dynamics and human injury responses.

NHTSA also actively participates in both the Departmental T2 Working Group (T2WG) and the Public Access Implementation Working Group (PAIWG). The efforts of the T2WG are aimed at improving existing information sharing efforts, developing more efficient processes, and identifying new methods of technology transfer. The T2WG provides an opportunity to share and gather information across USDOT operating administrations for successful and effective T2 transfer strategies. NHTSA Research continues to work with the PAIWG to provide greater continuity and coordination of information across sites and databases as these efforts directly feed into T2.

	FY 2021 Enacted ($000)	**FY 2022 Pres. Budget ($000)**	**FY 2022 Bipartisan Infrastructure Law ($000)***
R&DT Program Total	49,954	65,968	60,763

*The recently enacted Bipartisan Infrastructure Law (BIL) authorized R&DT totals greater than funding discussed in detail in this AMRP. The total funding amounts are shared in this table while a continued effort is underway to assess and implement use of these funds.

Table 1 - 2022 RD&T Program Funding Details
$65,967,689

RD&T Program Name	FY 2022 Pres. Budget ($000)	Applied ($000)	Technology Transfer ($000)	Facilities ($000)	Experimental Development ($000)	Major Equipment R&D Equipment
Vehicle Electronics and Cybersecurity	$4,464	$4,464				
Automated Driving Systems	$10,000	$10,000				
Advanced Safety Technologies	$18,120	$18,120				
Crashworthiness	$12,927	$12,927				
Alternative Fuels Vehicle Safety	$2,100	$2,100				
Vehicle Research & Test Center	$500			$500		
Program Execution Expenses	$3,501	$3,501				
Highway Safety Research	$14,356	$14,356				
Totals	$65,968	$65,468		$500		

Alignment: NHTSA's research programs are in alignment with the USDOT's strategic goals of safety, economic growth, equity, climate solutions and transformation, as well as the Agency's safety mission to save lives, prevent injuries and reduce economic costs due to road traffic crashes, through education, research, safety standards and enforcement activity. NHTSA's research focuses heavily on safety -- prioritizing the reduction of death and injuries in our nation's transportation systems. One of NHTSA's top focus areas for safety is protecting and avoiding vehicle crashes with vulnerable road users. The Agency is researching new warning/braking technologies and vehicle front end designs that reduce crashes and improve safety for people both inside and outside the vehicle. NHTSA is also conducting research to support electric vehicle and alternative fuel vehicle safety to reduce greenhouse gas emissions and work towards net-zero emissions by 2050. At the Departmental level, surface transportation safety is measured through annual overall outcome on performance measures with the goal of reducing the fatality rates of passenger vehicle occupants, vulnerable road users (pedestrians and bicyclists), motorcycle riders, and large/medium-duty truck and bus occupants. NHTSA also has agency-specific strategic goals with specific performance indicators it tracks, monitors, and reports on surrounding safety.

FY 2022 RD&T Program Budget Request by DOT Strategic Goal

RD&T Program Name	FY 2022 Pres. Budget ($000)	Safety ($000)	Economic Strength and Modernization ($000)	Equity ($000)	Climate and Sustainability ($000)	Transformation ($000)	Organizational Excellence
Vehicle Electronics and Cybersecurity	$4,464	$4,464					
Automated Driving Systems	$10,000	$10,000					
Advanced Safety Technologies	$18,120	$18,120					
Crashworthiness	$12,927	$12,927					
Alternative Fuels Vehicle Safety	$2,100	$2,100					
Vehicle Research & Test Center	$500	$500					
Program Execution Expenses	$3,501	$3,501					
Highway Safety Research	$14,355	$8,000		$2,356		$4,000	
Totals	$65,967	$59,612		$2,356		$4,000	

Chapter 1 - FY 2022 RD&T Programs

Office of Vehicle Safety Research (VSR)

Program Name: Vehicle Electronics and Cybersecurity
$4,464,000

Program Description: The evolution of automotive technology has included the expanded use of electronic systems, software, and wireless connectivity. This process started in the late 1970s and the pace of technological evolution has increased significantly over the past decade with vehicles becoming one of the most complex computerized consumer products. Enhanced wireless connectivity and continued innovations in electronic control systems introduce substantial benefits to highway transportation safety, mobility, and efficiency. However, with the increasing proliferation of computer-based control systems, software, connectivity, and onboard data communication networks, modern vehicles need to consider additional failure modes, vulnerabilities, and threats that could jeopardize benefits if new safety risks are not appropriately addressed. Connectivity and safety technologies that can intervene to assist drivers with control of their vehicle (e.g., automatic emergency braking) could also raise the cybersecurity stakes, and without proactive measures taken across the vehicle lifecycle, risks could rise accordingly. Methodical identification of potential issues and proactive management of increased risks related to advanced electronic and software-controlled systems are essential to designing vehicle architectures that will respond safely even when there are electronic system failures, software errors, or malicious software attacks.

The Vehicle Electronics and Cybersecurity research program broadly covers two major research areas: *Electronics Functional Safety* and *Vehicle Cybersecurity*. Electronics Functional Safety is an important part of overall systems safety that analyzes safety risks associated with potential failures in sensors, components, systems, and software implementation, as well as risks associated with predictable operator errors and/or infrequently occurring operational circumstances (the latter is referred to as the "Safety of the Intended Functionality," or SOTIF). Vehicle Cybersecurity research deals with safety risk management associated with intentional manipulation of software, hardware, sensors, and/or communication networks on-board the vehicle by malicious actors.

Program Objectives: The goal of the Vehicle Electronics and Cybersecurity research program area is to support enhanced reliability and resiliency of vehicle electronics, software, and related vehicle control systems to both mitigate safety risks associated with failure and/or cybersecurity compromise of such systems, but also so that such concerns do not pose public acceptance barriers for proven safety technologies and emerging ADS. The program seeks to support

improvements in the cybersecurity posture of motor vehicles, and understand and promote contemporary methods in software development, testing practices, and requirements management to address underlying hazards and risks across the vehicle life cycle. These activities include close collaboration with industry to promote a strong cybersecurity risk management culture and associated organizational and systems engineering processes.

Anticipated Program Activities:

Functional Safety

Research will focus on methods for assessing the functional safety of safety-critical subsystems including, but not limited to steering, braking, propulsion, perception, prediction, and decision-making systems. Failures of individual functional components are inevitable, and lacking a human operator as a fallback mechanism, ADAS- and ADS-equipped vehicles will be expected to have sufficient redundancy to sustain system operations for a period necessary to support fail-safe or fail-operational strategies. Research will include application of functional safety methodologies to electronic controls, software, processors, and electro-mechanical actuation systems employed by both ADAS and ADS-equipped vehicles. For FY 2022, the research scope extends to new capabilities ADS developers are introducing including using wireless communications to facilitate remote manual operation (or intervention) of the vehicle (i.e., teleoperations). Research will be initiated to characterize functional safety requirements for key heavy vehicle support systems, such as electronic controlled braking and electronic power steering systems for heavy vehicles, and to analyze the functional safety of a reference SAE International driving automation Level 4 vehicle implementation.

In executing functional safety analyses, NHTSA will leverage evolving industry process standards (such as ISO 26262, "Road vehicles – Functional safety") as well as traditional hazard assessment techniques, such as failure modes effects analysis (FMEA) and fault tree analysis (FTA) for the electronic systems and software of various types of driving automation systems. NHTSA will also conduct analyses related to the SOTIF using industry standards (such as ISO 21448, "Road vehicles – Safety of the intended functionality") for assessing reliability, safety and potential unintended consequences associated with electronic control software, and electro-mechanical systems due to misuse and/or misapplication beyond their intended functionality and operating domain. We will also explore contemporary methods in automated tools and approaches in software development, testing, and deployment, such as formal methods, and their potential applicability to automotive applications.

Vehicle Cybersecurity

NHTSA will continue research to advance the automotive industry's adoption and implementation of the National Institute of Standards and Technology (NIST) Cybersecurity Framework across their organizations and products. This will include targeted research on how the auto industry addresses the full lifecycle of cybersecurity risks including identifying,

protecting, detecting, responding, and recovering from cybersecurity threats. Further, NHTSA's research will support the interpretation and application of automotive-focused cybersecurity standards by vehicle manufacturers and suppliers. In FY 2021, this research helped support the development of NHTSA's "Cybersecurity Best Practices for the Safety of Modern Vehicles." VSR's research to support potential refinements, expansions, and updates to this document will continue in FY 2022.

NHTSA's cybersecurity research program is cross-cutting in that results will generally be applicable to conventional vehicles as well as those equipped with ADAS and ADS technologies. Research programs will include:

- Research in support of industry cybersecurity self-reporting and monitoring activities. This research will include on-going monitoring of industry standards activities, and support and representation for international cybersecurity standards development efforts.
- Research in support of developing vehicle cybersecurity training materials and their pilot testing to foster cybersecurity best practices element in workforce development and facilitate better cybersecurity related knowledge sharing among the members of the industry.
- Research on cybersecurity assessment and testing methods that explores the development of cybersecurity assessment methods that may be applied to a motor vehicle and its associated information sources and access paths (e.g., telematic services, repair and warranty activities, connectivity (cellular) providers, etc.). This research also includes investigating cybersecurity assessment approaches used in other industries involving cyber-physical systems and adapting them as appropriate for the automotive sector. Development of potential cybersecurity and resiliency metrics are also within VSR's research interests.
- Research to enhance cybersecurity response readiness will explore and support industry's and NHTSA's abilities to continually improve and assess organizational readiness to respond to potentially critical and large-scale cybersecurity incidents. This would include exercises engaging industry stakeholders, all relevant departmental organizations, and other Government agencies to practice and refine internal processes. This activity will include additional investments in NHTSA's applied cybersecurity capabilities to maintain technical expertise, assess emerging issues independently and expeditiously, and facilitate informed decision-making related to cybersecurity incidents.
- Research related to cybersecurity data analytics includes exploring relevant cybersecurity data and analyses techniques that can be applied by a vehicle manufacturer (as well as suppliers and/or telematic service providers) to help with early identification of potential cybersecurity threats; preparation of response plans, and support of post-exploit forensic analysis to help improve future system designs and response mechanisms.

- Research related to assessing the cybersecurity and resilience of electric vehicle battery management systems will focus on identifying potential battery management systems' cybersecurity considerations, as well as examining the resiliency concepts of for deployed systems in the face of a cybersecurity attack.
- Research to help understand how motor vehicle cybersecurity resiliency and threat surfaces have evolved over the past decade as vehicles have expanded their connectivity pathways with infrastructure-based systems and other devices, but also designed-in protections in new electrical architectures.

Expected Program Outcomes: While no crashes or fatalities have been directly attributed to a real-world vehicle cybersecurity incident, the potential for large scale cyberattacks on vehicles is well-recognized, and as such, this risk warrants pre-emptive and proactive attention. Further, cybersecurity vulnerabilities may also influence public confidence in our Nation's transportation system and could create a roadblock for the adoption of proven safety technologies as well as future ADS-equipped vehicles. If not appropriately addressed through design and lifecycle risk management processes, a successful cyberattack on automotive computer systems and their associated networks may not only lead to the loss of information and data but may also adversely impact vehicle control systems such as steering, braking, and throttle, potentially resulting in crashes and injuries. Therefore, electronic systems' safety and cybersecurity will play an important role in public acceptance of emerging technologies, such as ADAS and ADS technologies, that have the potential to significantly reduce motor vehicle crashes.

Collaboration Partners: Collaborate and leverage research with key stakeholders, the automotive industry, standards setting organizations, and government agencies to include Automotive Information Sharing and Analysis Center (Auto-ISAC), Original Equipment Manufacturers (OEMs), automotive suppliers, ADS technology companies, Department of Homeland Security (DHS), ISO, NIST, Department of Defense (DOD), and SAE International.

Program Name: Automated Driving Systems (ADS)

$10,000,000

Program Description: While limited ride-hailing and product delivery demonstrations or deployments are beginning to emerge and may be opened to the public, vehicles equipped with ADS remain primarily in the development and testing phases. A vehicle equipped with an ADS, when engaged, can perform the full driving task within its operational design domain without an expectation of an engaged driver. ADS-equipped vehicles, at maturity, hold the potential to improve safety beyond levels achievable with ADAS alone. As a result, ADS research continues to be an important area for NHTSA.

Program Objectives: This program objectives of the ADS research area include NHTSA's efforts in the following tracks and are primarily focused on supporting the safe deployment of ADS-equipped vehicles:

- Compatibility research of ADS-equipped vehicle designs with respect to existing FMVSSs.
- Tools and methods to assess the safety performance of ADS-equipped vehicles.
- Crashworthiness research to address new seating arrangements and other novel design elements anticipated with ADS-equipped vehicles.
- Human factors research to support safe and effective communications between ADS-equipped vehicles, passengers, and other road users.

Anticipated Program Activities: In FY 2022, the ADS research program will support work in the following areas:

FMVSS compatibility of (ADS) vehicle designs: With ADS, vehicle manufacturers are presented with opportunities to re-imagine and redesign new vehicle platforms without conventional driver controls such as a steering wheel, accelerator pedal, or brake pedal—and with very unconventional seating arrangements. However, such changes may create compatibility challenges with existing FMVSSs and research is needed to understand if and how those conflicts may relate to safety performance.

In ADS-equipped vehicles without conventional driver controls, occupants will have more freedom to choose seats other than the front left (traditional driver's seat). Increased occupancy in the rear row, as well as seating preference in vehicles with unconventional seating

arrangements, will impact occupant protection and how information is communicated to occupants. Research on occupant seating preferences began in FY 2021 and will continue in FY 2022. This will include a test track study with volunteers riding in various ADS-equipped vehicles. Seating and interaction with the ADS-equipped vehicle will be monitored and analyzed.

Research on ADS safety performance: This research will explore methods, metrics, and tools for assessing the safety of ADS-equipped vehicles. Research will focus on advancing multiple assessment methods, including modeling and simulation, closed course testing, and on-road naturalistic testing. The research will also include working with industry standards organizations in developing a common language for describing ADS test scenarios, and methods for selecting specific test scenarios to efficiently test ADS capabilities or attributes of interest. Additional research will focus on evaluating the application of community proposed analytical methods that leverage operational data (or results) from various testing venues to develop safety performance metrics.

For 2022, NHTSA will advance our research related to ADS-equipped vehicle subsystems, including methods for examining performance of ADS sensors and perception systems. This will include methods to assess pedestrian recognition performance across a diverse population of road users to encourage equity and inclusiveness during the design process. In FY 2022 we will also initiate development of methods for evaluating performance of maneuver execution sub-systems and the ability of the vehicle to accurately follow path-planning instructions from the ADS's decision support system.

We will expand our development of on-road ADS testing methods to include a focus on heavy vehicles, and we will advance our capabilities for executing multi-agent test scenarios in controlled (test track) environments.

NHTSA will also initiate research related to the role fleet operators will play in maintaining ADS safe operations, as well as investigating issues related to ADS maintenance and reliability generally. Finally, work started in FY 2021 on safety issues associated with ADS teleoperations and use of high-definition maps will continue in FY 2022.

Crashworthiness of ADS-equipped vehicles: Vehicles equipped with ADS may incorporate novel occupant compartment designs and seating conditions. Side- and rear-facing seat positions are common for transit buses and may be considered for smaller, higher-speed ADS-equipped vehicles. Changes in occupant seating and restraint systems will affect the ADS-equipped vehicle occupant's response in a crash and the associated injury scenarios and risk factors. In FY 2022, initial research will be conducted using Human Body Models (HBM) to evaluate occupant restraints for the range of seating conditions expected in new ADS designs. In FY 2022,

research will refine understanding of human response and injury metrics for various alternative seating and crash conditions, and this understanding will drive further adaptations to anthropomorphic test devices (ATDs) for use in forward- and rear-facing reclined seating configurations. The Agency will also continue to develop best practices for safe interaction of non-occupied ADS-equipped vehicles with existing vehicles, roadside hardware, pedestrians, cyclists, and motorcyclists.

Human factors research to support safe and effective communications between ADS-equipped vehicles, passengers, and other road users: ADS-equipped vehicles and ADS-Dedicated Vehicle (ADS-DV) designs will influence humans' interactions with vehicles. The Agency will continue to investigate emerging ADS human factors topical areas (e.g., external HMI, driver-vehicle interface (DVI), communication of intent, etc.). In FY 2022, NHTSA will continue to research different methods to transfer knowledge from the ADS to the driver/operator to improve situation awareness and accelerate the transfer of control. In some situations, it may be necessary for a remote operator to take over control of an ADS-DV. The Agency will continue to execute research to better understand the human factors considerations associated with remote operation.

ADS-equipped vehicles may provide mobility options not previously afforded to people with disabilities—cognitive, physical, and/or sensory—or even the degree of the disability. In FY 2022, human factors research will be performed to better understand information needs necessary to establish situation awareness for people with varying disabilities riding in ADS-equipped vehicles (e.g., information needs be for someone with a visual impairment vs someone with a mobility aid).

Vehicles equipped with ADS that are accessible to people with disabilities will be expected to provide safety equivalent to those having standard seating conditions. NHTSA will evaluate side impact test methods for near side impact crashes involving occupants seated in wheelchairs. Research will continue to explore the information needs of persons with disabilities.

ADS-equipped vehicles will likely be utilized for the transport of children. Research will be conducted to explore child-specific safety considerations in ADS-equipped vehicles. This research will continue to examine safety considerations for child restraint system (CRS) installation and usage in unconventional seating conditions anticipated for future ADS-equipped vehicles. Research related to safety and operational considerations for remote teleoperations of ADS-equipped vehicles with unattended children as passengers will continue. Sensor systems will be evaluated for the ability to detect unattended children and prevent heat stroke occurrence.

Expected Program Outcomes: The U.S. plans to maintain its international leadership position in ADS development through continued joint efforts of the government, private sector,

universities, and other transportation stakeholders. As such, NHTSA is focusing research on key topics to advance the safe testing and deployment of ADS-equipped vehicles that do not require a human driver. Preliminary research indicates that if deployed responsibly, there could be significant safety benefits associated with ADS-equipped vehicles. Further, ADS-equipped vehicles offer access to mobility for previously underserved communities of individuals unable to acquire a driver's license, including older adults and people with disabilities—cognitive, physical, and/or sensory. The FY 2022 budget request enables research that supports objectivity and comprehensiveness in ADS safety evaluation methods, development of transparent and explainable safety metrics, and which focuses on a data-driven approach to develop an effective and efficient safety assessment framework.

Collaboration Partners: NHTSA will collaborate and leverage research with key stakeholders, including the automotive industry, standards setting organizations such as SAE International USDOT operating administrations and other Government agencies, ADS technology companies, NIST, ISO, and academia.

Program Name: Advanced Safety Technology
$18,120,000

Program Description: Advanced Safety Technology research focuses on motor vehicle technologies and systems that assist drivers in avoiding crashes. These could include traditional crash avoidance technology (i.e., tires, brakes, lighting) as well as ADAS features (collectively SAE driving automation Levels 0-2). The research program covers passenger vehicles, medium and large trucks, buses, motorcycles and vulnerable road users. As roadway safety continues to be a major public health and economic challenge in the U.S., motor vehicle safety remains a key priority of the USDOT. Despite decades of progress on reducing passenger vehicle fatalities, an unacceptable number continue to occur on U.S. roadways. Furthermore, increases have occurred in pedestrian, pedal-cyclist, motorcyclist and other vulnerable road user fatalities. These crashes contribute to significant societal harm and economic cost. VSR's research program aims to target technologies that have the potential to reduce high frequency crashes, as well as improve the safety of vehicle occupants, pedestrians, bicyclists, motorcyclists, and other vulnerable road users. The potential role and impacts of connectivity in improving vehicle safety are also considered in this program.

In recent years, an increasing number of new vehicles feature ADAS technologies designed to assist drivers by providing warnings when a crash seems likely or, in some cases, temporarily engaging active vehicle control for avoiding/mitigating crashes. This program area focuses on the safe development, evaluation, and deployment of ADAS technologies, ranging from those that respond to specific crash-imminent situations with brief control interventions (SAE driving automation Level 0) to systems that enable sustained interventions considered partial driving automation but still require full driver engagement (SAE driving automation Levels 1 and 2).

Primarily, SAE Level 0 systems included in the 2022 research program are rear-end crash prevention systems (e.g., light and heavy vehicle automatic emergency braking), pedestrian crash avoidance (e.g., forward/rearward pedestrian automatic emergency braking, and intersection collision avoidance (e.g., cross-traffic alert systems). For driving automation systems, the program focuses on SAE Level 1 and 2 driving automation systems to further study lane centering technologies and human factors issues surrounding driver engagement. Additional crash prevention issues of research interest include lane/change merge crash prevention (e.g. blind spot intervention systems), run off road avoidance (e.g. lane keeping support systems), and combinations of systems to enable features such as traffic jam assist (TJA).

Significant progress has been made in the development of advanced safety technologies intended to prevent and/or mitigate roadway crashes. Today's crash avoidance systems rely on an array of sensors (e.g., radar, lidar, video/image analysis, etc.) to detect objects within the vehicle's operational environment. The vehicle's computing and software functions apply the sensing

inputs to classify the objects, assess the likelihood of potential collisions, or lane departures. The vehicle may warn the driver to take appropriate action, or some advanced safety systems may also automatically apply the vehicle's brakes or initiate steering to help avoid or mitigate a crash.

The effectiveness of advanced safety technologies often relies on the performance of the (human) driver as they interact with the system—ranging from simply whether (or not) drivers engage or disengage a system (e.g., lane departure warning) to how warnings are issued through the driver-vehicle interface. Similarly, more advanced driving automation systems include applications and performance that rely on the driver's ability to: properly understand the capabilities, constraints, performance limitations, and operational boundaries of the systems. Human drivers must also clearly understand when they are expected to regain full control of steering and acceleration/braking when interacting with SAE driving automation Level 2 systems, which are implemented differently across manufacturers.

Program Objectives: The principle objective of this program is to carry out safety research to advance and accelerate the deployment of proven safety technologies across the U.S. automotive fleet. This program is focused on safety systems and innovations that directly map to crashes involving light and heavy vehicles, motorcycles, and other vulnerable road users. Research is conducted with the objectives of attaining a comprehensive understanding of related ADAS-enabling technologies, such as underlying sensors. Research also encompasses quantifying ADAS performance, capabilities, limitations, effectiveness, and potential new risks for all classes of vehicles and all roadway users.

This program will continue to focus on emerging safety technologies and innovative safety systems that show potential to address real-world crashes and improve vehicle safety performance. This includes reducing the number and severity of crashes with other vehicles and, vulnerable road users (e.g. pedestrians, bicyclists).

Anticipated Program Activities: In FY 2022, the Advanced Safety Technology research program supports both the ADAS and Heavy Vehicle Safety Technologies programs. Requested funding will support the following areas:

Safety Performance Assessment of ADAS Technologies: This work will include the safety performance assessment of ADAS technologies deployed in new production motor vehicles including light and heavy vehicles. The assessment will include safety performance evaluations through computer simulations, closed-course testing, and/or naturalistic roadway evaluations. Research includes development of objective test procedures that will facilitate decisions related to updates to the New Car Assessment Program (NCAP) or potential new regulations. Additionally, NHTSA's simulation capability for light vehicles is also validated through the data

obtained via this testing and updated to estimate effectiveness measures with additional ADAS applications.

ADAS Innovation and Deployment: Innovative technologies considered for research include active safety systems that could be considered in future policy considerations such as cross-traffic alert systems that have potential to address some types of intersection crashes, and blind spot intervention systems that automatically initiate steering or braking to assist drivers with avoiding lane change/merge collisions, opposite direction (head-on) collision avoidance systems. Other research will include new developments in lighting systems, camera-based mirror alternatives and heavy-vehicle braking systems

As sensor and software capabilities mature, the market is evolving with increasing proliferation of systems featuring partial driving automation systems that could be classified at SAE driving automation Level 2, which provide both lateral and longitudinal vehicle motion control. This program will perform research in assessing and supporting the advancement of the safety performance of such systems while appropriately managing driver complacency risks. In SAE Level 2 driving automation, the driver is expected to be fully and continually engaged in the driving task while the system is enabled. Further research insights are needed in the implementation strategies for drivers' interaction with these systems, and the utility and performance of different attention management approaches as they pertain to roadway safety. Human factors challenges and associated best practices with these new technologies will be continually evaluated.

*ADAS Human-Machine Interface (HMI)***:** Advanced vehicle safety technologies that support the driver have a range of interaction points when information is communicated to the driver and responses are expected. Head-up displays, gesture-based inputs, and augmented reality displays are some examples of emerging in-vehicle HMI technologies. Similarly, the expected response to HMI warnings and alerts is evolving as in-vehicle technology changes. These alerts include brake pulses, haptic seat/steering wheel vibrations, and auditory chimes. NHTSA's research program encompasses a broad HMI design concept.

Driver Interactions with ADAS: When examining the cooperation between drivers/users and vehicles/systems, it is critical to measure behavioral changes that could occur beyond reactions to HMI, such as the choices drivers make for trip planning and the strategies they employ when driving. Behavioral adaptations represent a significant point of uncertainty about the effectiveness of ADAS systems and sometimes undermine efforts to address a safety issue using technology. Driver responses to ADAS systems, in contrast to conventional vehicles, are of key importance to understanding the benefits of ADAS.

Driver Engagement and ADAS: A driver's readiness to resume control when an ADAS issues a request to intervene is critical to safety. Vehicles that are designed to toggle control between the driver and the SAE driving automation Level 2/3 system need to transfer control back to the driver. Making sure that the driver is attentive to the roadway situation is important to safe and timely transfer of control. NHTSA will explore driver engagement strategies such as applying enough force to the steering wheel or simply looking at the roadway ahead, and others that have been studied in other fields such as rail, and aviation fields. Similarly, driver monitoring systems offer the potential to determine driver state of attentiveness. NHTSA will continue to research driver monitoring systems. This research explores a variety of monitoring system types, their operation, alerts, and relative effectiveness.

Heavy-Duty Safety Technologies: This program is focused on safety systems and innovations that directly map to crashes involving heavy- and medium-duty vehicles on U.S. roadways. Research in this program area will focus on identifying and addressing the real-world target crashes involving trucks that result in the highest societal costs, while highlighting the special considerations associated with, and quantifying the benefits stemming from, the application of ADAS technologies in heavy- and medium-duty vehicles.

Expected Program Outcomes: The light vehicle Advanced Safety Technology research program aims to advance the safe deployment of life saving ADAS technologies within the SAE driving automation Levels 0-2 category. The research program is engaged in a body of research for vehicle technologies that supports safer drivers by presenting them with safety warnings and when needed, providing active assistance through automatic interventions in crash imminent situations, and discouraging unsafe driving behaviors such as distracted and alcohol-impaired driving through technological solutions. Research also focuses on technologies that enhance the safety of vulnerable and at-risk populations, such as pedestrians, bicyclists, and motorcyclists. NHTSA's research in ADAS will continue to focus on: identifying emerging safety technologies; partnering with industry to develop more efficient and comprehensive assessment methods for safety performance and enhancing our understanding of HMI issues; and optimizing the long-term safety impacts while mitigating risks in deployment of these advanced technologies.

The outcome of this work will be research findings related to critical aspects of ADAS, such as effective HMI design and system operation characteristics to complement driver performance, maximize safety benefits, and establish validated performance-based test procedures. These and other outputs from this program will enable automotive manufacturers, suppliers, and other industry entities to apply modern technology to improve the safety performance of their products through more accurate and efficient product evaluations, thereby enhancing societal safety benefits. Furthermore, the field testing of emerging ADAS technologies by NHTSA and industry partners will provide insights for further product refinements, as well as for developing programs to promote voluntary adoption of crash avoidance systems and enhance

competitiveness among vehicle manufacturers and other industry entities offering high-value and high-performance safety systems.

The Heavy Vehicle Safety Technologies program is focused on safety systems and innovations that directly map to crashes involving heavy vehicles on U.S. roadways. By continuing to focus on emerging innovative safety systems on heavy vehicle platforms that show potential to address real-world crashes, the safety performance of heavy vehicles—with respect to frequent and severe crashes—may be significantly improved.

Collaboration Partners: NHTSA will collaborate and leverage research with key stakeholders, including the automotive industry, standards setting organizations such as SAE International, USDOT operating administrations, other government agencies, ADS technology companies, U.S. NCAP and other global NCAP programs.

Program Name: Crashworthiness
$12,927,000

Program Description: Crashworthiness research focuses on vehicle safety countermeasures to reduce the number of fatalities and serious injuries that result from motor vehicle crashes in the United States each year. This research program is responsible for developing and upgrading test procedures for the evaluation of motor vehicle safety, and for developing evaluation tools (e.g., crash test dummies and human body computer models) and appropriate injury metrics. Crashworthiness research encompasses new and improved vehicle designs, equipment and safety countermeasures; biomechanics and injury causation; real-world field data collection and analysis of serious injury cases; and computer modeling based research all aimed at enhancing outcomes for motor vehicle occupants and vulnerable road users. The program directly supports the Department's goal of reducing transportation-related fatalities and serious injuries across the transportation system.

Program Objectives: The purpose of the Crashworthiness research program is to investigate the problems of vehicle crash safety and associated factors (e.g., vehicle design, human response/injury tolerance) that contribute to serious injuries and fatalities. The near-term goal is to identify fatality and injury trends and to enhance safety requirements and best practices to improve crash outcomes for vehicle occupants and vulnerable road users. This program supports the Department's critical research priority to improve safety.

Biomechanics research makes significant contributions to safety by developing publicly available data, tools, performance measures, and procedures that NHTSA and industry use, both to understand how vehicle occupants and vulnerable road users are injured in crashes and for assessment of vehicle safety countermeasures. Biomechanics research also works with trauma centers to understand the detailed nature of injuries. The causes of these injuries are evaluated through laboratory test programs and computer simulations. The new knowledge that is gained through injury research is applied towards the development, evaluation and refinement of crash test dummies and associated injury measures as well as towards the enhancement of computer models (e.g., human body models). These tools are then utilized to support vehicle safety countermeasure development for occupants of all ages, size and gender.

In 2022, Biomechanics research will continue to focus on completing the development, evaluation, and documentation associated with advanced testing and simulation tools (ATDs, human body models). The application of these enhanced tools will increase both the Agency's and industry's ability to assess occupant protection safety in frontal, side, oblique, and rear impact crash modes. Included in these efforts is research supporting the completion of testing, evaluation, and documentation associated with a new small female frontal impact crash test dummy (Test Device for Human Occupant Restraint or THOR 5th percentile female crash

dummy). Related to both the THOR 5th female crash dummy and human body models, there will continue to be an emphasis on researching differences in injury risk between males and females. Research supporting the development and documentation of the THOR 5th female crash dummy will continue to include efforts to develop and utilize female-specific response and injury data for use in developing injury criteria. Research concerning human body models will include the development and application of a 50th percentile female.

Additionally, the program focuses on vulnerable populations (e.g., pedestrians, children, and older occupants). Pedestrian research will focus on completing and evaluating test tools to assess vehicle countermeasures addressing pedestrian safety. Older occupant research focuses on evaluating leading injury mechanisms for older occupants: brain injuries (subdural hematoma) and thorax injuries.

Safety Systems research is responsible for evaluating new crash safety concerns and for developing safety concepts, test procedures, and performance measures. Safety Systems research examines existing designs, new and improved vehicle designs, safety countermeasures, materials, and equipment to enhance safety for all occupants in the event of a crash.

In 2022, Safety Systems research will use the tools and criteria developed through Biomechanics research to develop strategies for achieving equitable safety for occupants with diverse body sizes and shapes. Child safety continues to be a major focus area, with research toward improving the frontal crash performance of child restraints, including larger children in booster seats. Occupant safety in front and side crashes will be assessed using new, advanced crash test dummies. Frontal crash protection will also focus on improving safety for rear seat occupants, including continued evaluation of seat belt elongation requirements, research to reduce head injuries from contacts with seat backs and interior surfaces, and seat back strength in rear impacts.

The Crashworthiness research program supports the entire private sector rather than benefitting any single company. Research on evolving crash injury mechanisms and the development of safety assessment tools is intended for widespread use in automotive design.

Anticipated Program Activities: Safety Systems will support research to evaluate new test dummies and injury metrics in current and future crash conditions, develop or revise test procedures, and assess the effectiveness of occupant protection systems. Biomechanics will fund research to develop tools (crash test dummies, mathematical models) and injury metrics that can be applied towards the assessment of advanced vehicle safety countermeasures. Specifically, the funding requested in FY 2022 will allow NHTSA to carry out crashworthiness research activities including technical documentation for an advanced crash test dummy, the small adult female frontal dummy (THOR 5th percentile); conducting research and testing with the THOR 5th percentile female dummy to evaluate its sensitivity to changes in crash type and restraint

configurations; research and testing to assess rear seat occupant protection for adults and children, including head protection, restraint performance, consequences of seat belt elongation, and booster seat performance; research focused on injury risk differences between females and males and analysis of existing and/or collection of new female-specific data to be used in conjunction with the THOR 5th percentile female crash dummy (e.g., injury criteria development); developing head/brain injury criteria specific to the protection of older occupants; collect real-world motor vehicle crash occupant-based injury data, known as the Crash Injury Research and Engineering Network (CIREN).

Expected Program Outcomes: The Crashworthiness research program supports the Department's and Agency's goal of enhancing safety for all occupants and vulnerable road users using several strategies, which include data risk identification, collaboration, leadership, performance, coordination, research, and technology integration. The outcomes provide information to support Agency decisions on actions aimed at reducing the number of fatal and serious injuries to occupants in motor vehicles that occur in the United States each year from crashes. The knowledge, tools, test procedures, and injury metrics resulting from this research program can be used by industry and the vehicle safety community to provide improved crash safety in vehicle designs.

The Biomechanics research program at NHTSA has long maintained a leadership role in the development of test tools (e.g., crash test dummies) and injury metrics used to ensure optimal crashworthiness of vehicles. The Safety Systems research program is responsible for evaluating new crash safety concerns and for developing safety concepts, test procedures, and performance measures. Safety Systems research examines existing designs, new and improved vehicle designs, safety countermeasures, and equipment to enhance safety for all occupants in the event of a crash.

In FY 2022, NHTSA will continue to collaborate with industry and academia in supporting research that benefits the public by promoting the development of advanced tools and knowledge for applications that aim to reduce injuries/fatalities resulting from motor vehicle crashes. Below are some expected public benefits that will result from the FY 2022 budget request:

- Public release of CIREN dataset of detailed injury and medical data associated with seriously injured motor vehicle crash occupants.
- Continued public release of technical documentation for the advanced THOR 5th percentile female crash test dummy;
- Continued refinement, evaluation, demonstrated application, and public release of mathematical models such as detailed human body models, body region specific injury models, and dummy-based models along with test data and reports demonstrating model fidelity;
- Public release of test results through NHTSA's Biomechanics, Crash Test, and Component databases, which include over 20,000 NHTSA-funded or acquired tests. These

results are used by the Agency, academia, industry, safety advocate and research groups, and the public for a variety of purposes, including vehicle performance and injury assessment, test procedure and injury and criteria development, and consumer information;

- Public release of technical reports on frontal and side impact testing using advanced crash test dummies; and
- Public release of technical research reports on lower interior protection for rear seat occupants and seat belt elongation.

Collaboration Partners: NHTSA will collaborate and leverage research with key stakeholders, the automotive industry, standards setting organizations, and Government agencies, including OEMs, automotive suppliers, ADS technology companies, industry and academic consortiums, Department of Energy national laboratories, university-based research groups, and other USDOT modes.

Program Name: Alternative Fuels Vehicle Safety
$2,100,000

Program Description: NHTSA is gathering information from all sources regarding the safety of emerging transportation fuels including battery, stored gas, and fuel cell technologies. This advanced knowledge is helping to direct the research projects, refine safety assessments, and develop performance tests. NHTSA is partnering with industry and other federal agencies to develop appropriate safety performance considerations for these alternative fuel vehicles. This program will focus on demonstration of in-use diagnostic systems that monitor battery cell performance and alert prior to thermal breakdown. NHTSA will also coordinate with the Department of Energy (DOE) research to understand the safety of solid-state battery systems and begin consideration of the need for developing new performance test procedures. These technologies should all involve research between the DOE national laboratories, the automotive original equipment manufacturers (OEMs) and their suppliers. The planned research will also apply past research on charging safety to new battery designs and consider both commercial and residential applications.

Program Objectives: NHTSA is currently working with DOE to develop a test platform to assess the dynamic performance of lithium ion battery diagnostic systems. This system is intended to exercise the battery system in standard drive cycles while introducing abuse conditions for a subset of battery cells. The objective is to evaluate a range of diagnostic systems to understand their capability to detect Li ion cell breakdown prior to the onset of thermal runaway. NHTSA is also working with the Department of Homeland Security to document standards and best practices for emergency medical responders. This study will also document any difficulties EMS responders encountered in handling battery electric vehicle fires and stranded energy situations. Field safety incidents will be investigated and, where appropriate, best practices will be developed to enhance fleet safety. NHTSA will continue to partner with industry, standards organizations, and other Federal agencies to develop appropriate safety performance for new alternative fuel vehicles.

Anticipated Program Activities: NHTSA will continue to collaborate with other agencies on funding and other research programs. The program meets the annual funding Appropriations Act's requirement to conduct alternate fuels vehicle safety research.

Expected Program Outcomes: NHTSA has worked closely with the DOE to understand safety concerns for emerging alternative fuel vehicles. Past collaboration allowed NHTSA to develop and assess charging safety tests for a range of electric vehicle types and wired and wireless charging systems. NHTSA's research will develop a test platform and methods for evaluating battery damage prior to the onset of thermal failure. This research should encourage the development of safer vehicle systems and reduce the risk for emergency responders.

Collaboration Partners: NHTSA will collaborate and leverage research with key stakeholders, the automotive industry, standards setting organizations such as SAE International, and Government agencies, including OEMs, automotive suppliers, ADS technology companies, DOE National Laboratories, and other USDOT operating administrations.

Program Name: Vehicle Research and Test Center (VRTC)
$500,000

Program Description: VRTC is NHTSA's in-house applied research, development, test, and evaluation laboratory located in East Liberty, Ohio. Research and testing activities conducted at VRTC support Agency decisions and actions with respect to new vehicle systems and issues, Agency consumer information programs, test dummy development, injury criteria development, advanced research into cutting-edge technologies, and safety issues that require quick reaction, including defect investigations. The full range of testing and research capabilities available to NHTSA at VRTC allows the Agency to maximize its testing capabilities to more rapidly study emerging safety issues and more quickly provide benefits to the American public.

Program Objectives: VRTC supports a broad range of applied research in critical safety areas including:

- Crash avoidance research (light and heavy vehicles), including support for updating existing Agency safety tests and research of new emerging ADAS technologies. This program area also supports development of foundational tests, methods, and safety metrics to enable future Agency evaluation and policy decisions for emerging ADS technologies and includes human factors research to ensure that advanced technologies are used by drivers in ways that successfully reduce crashes;
- Crashworthiness research, including support for updating existing Agency tests and test procedures as well as research on new occupant protection topics to enable deployment of innovative new technologies;
- Biomechanics research, including adapting and upgrading existing tools (crash test dummies) for compatibility with new technologies such as ADS;
- Lab and in-field support for safety defects investigations; and
- Research into complex areas such as ADS and cybersecurity to support development of safety approaches, methods, and tests.

Research in these areas directly supports the Department's goal to reduce transportation related fatalities and serious injuries across the transportation system. This aligns with NHTSA's mission and the Department's goals to deploy new and innovative technologies.

Anticipated Program Activities: VRTC conducts testing, research, and development necessary to support Federal motor vehicle safety standards, recall of defective vehicles, and other safety-engineering objectives to address the crash safety problem. Through efforts in these areas, VRTC directly addresses the vehicle crash problem on our nation's roadways. Analysis of crash causation factors imply that a large majority of serious crashes are due to dangerous choices or errors people make behind the wheel. VRTC's research supporting improved advanced safety technologies, improved occupant protection in a crash, and emerging technology areas (e.g.,

driving automation) are addressing the driver error issue and other crash causation factors, such as vehicle defects. The program also addresses emerging cybersecurity issues and evaluates how new technologies and other vehicle safety innovations can potentially improve vehicle safety.

Research conducted at VRTC supports the Agency's fundamental role in vehicle safety programs that include activities such as safety defects investigation support and standards development, compliance testing, support for policy decisions with respect to advanced cutting-edge technologies, and support for safety issues that require quick Agency response. By their very nature, these are not areas that private industry can address. Other basic research on new and emerging issues is collaborative in nature, such as ADS testing, cybersecurity, biomechanics research on new test dummies, and new approaches to occupant protection. This research often involves automotive manufacturers and suppliers.

The FY 2022 funding will be used to procure equipment needed to conduct research and analysis of ADS equipped vehicles, cybersecurity, electric vehicles, other advanced technologies, or other research and defects analysis efforts to support Agency actions to improve safety on our nation's roadways. With new sophisticated electric-powered vehicles and electronic control systems emerging in the market, NHTSA needs to maintain a well-equipped and dedicated center to test, monitor, and investigate these and other emerging safety issues.

NOTE: The $500K in direct funding to VRTC is in addition to research funding to support the program areas cited above (vehicle electronics and cybersecurity, Automated Driving Systems, advanced safety technologies, and crashworthiness) and is in addition to support research done in collaboration with other offices within NHTSA (e.g., NHTSA enforcement and rulemaking) as well as offices within the Department (e.g., ITS JPO).

Expected Program Outcomes: The expertise and technical capability of NHTSA's VRTC has been well demonstrated for over 40 years. Numerous high-profile programs have been successfully completed by VRTC in an expeditious and thorough manner. At the same time, NHTSA has recognized the need to enhance the capabilities at VRTC for testing and analyzing emergent safety issues. Providing the capability of testing emerging technologies is necessary to maintain pace with the rapid advances in vehicle technologies and electronics and the resulting new safety issues. While enhancement of research capability in several areas has been identified, the most near-term critical area is evaluating and developing laboratory capabilities in the rapidly accelerating area of electric vehicle (EV) deployment and the associated need for NHTSA to have the resources and facilities to adequately test and evaluate EVs, particularly battery safety. Enhancement of capabilities for performing safety related research, testing, and analysis is critical. The FY 2022 budget request enables VRTC to maintain and update the equipment and facilities necessary to assess and investigate the rapid emergence of advanced automotive safety technologies, and to assure the highest level of automotive safety for the American public.

Collaboration Partners: NHTSA will collaborate and leverage research with key stakeholders, the automotive industry, standards setting organizations, universities, and Government agencies, including OEMs, automotive suppliers, ADS technology companies, NIST, SAE International, The Ohio State University, Transportation Research Center, and other USDOT operating administrations.

Office of Behavioral Safety Research (BSR)
Program Name: Highway Safety Research
$14,355,689

Program Description: Highway Safety Research provides the scientific basis for the development of effective behavioral countermeasures to reduce the occurrence and severity of traffic crashes. Highway Safety Research also evaluates the effectiveness of programs to reduce fatalities and injuries on our highways, which is critical to assist States in allocating resources effectively and achieving national performance targets. In addition, Highway Safety Research monitors and measures both safe and unsafe driving behaviors to track progress and identify emerging safety problems.

NHTSA's Highway Safety Research program supports the Department's safety efforts through behavioral research, demonstrations, technical assistance, and national leadership activities emphasizing alcohol- and drug-impaired driving countermeasures, occupant protection, distraction, traffic law enforcement, emergency medical and trauma care systems, driver licensing, State and community traffic safety program evaluations, motorcycle rider safety, pedestrian and bicyclist safety, pupil transportation, and young and older driver safety programs.

Highway Safety Research also funds the Driver Alcohol Detection System for Safety (DADSS) project. Despite progress over the past three decades, drunk driving claims approximately 10,000 lives each year. The DADSS project is researching a first-of-its-kind technology that holds the greatest potential we have seen to reverse this trend. The technology is being designed to automatically detect when a driver is intoxicated with a BAC at or above 0.08% — the legal limit in all 50 states except Utah — and prevent the car from moving. Once it has met rigorous performance standards, it will be voluntarily offered as a safety option in new vehicles, similar to automatic braking, lane departure warning and other advanced driver assist vehicle technologies.

Lastly, Highway Safety Research funds the Behavioral Traffic Safety Cooperative Research Program (BTSCRP). BTSCRP, which is administered by the Transportation Research Board, is a forum for coordinated and collaborative research to address issues integral traffic safety professionals at all levels of government and the private sector. BTSCRP provides practical, ready-to-implement solutions to save lives, prevent injuries, and reduce costs of road traffic crashes associated with unsafe behaviors.

BTSCRP serves as an accelerator of research to practice and technology transfer. Products are developed in response to problems faced by traffic safety stakeholders. Emphasis areas are alcohol-impaired driving, autonomous vehicles, bicyclists and pedestrians, child passenger safety, distracted driving, drowsy driving, drug-impaired driving, law enforcement, mature drivers, motorcyclist safety, seat belts, speed and safety cameras, speeding and aggressive

driving, teen driver safety, and traffic records. BTSCRP will produce a series of research products that traffic safety stakeholders, government agencies, and other interested parties will be able to quickly use or implement in their traffic safety practices. TRB released the first set of products in March 2021 for Using Electronic Devices While Driving: Legislation and Enforcement Implications.

Program Objectives:

Research will support five overlapping strategic goals:

- Preventing destructive traffic safety behaviors;
- Encouraging positive traffic safety behaviors;
- Leveraging public safety to improve traffic safety;
- Protecting vulnerable road users; and,
- Exploring advanced technologies to address traffic safety issues.

Anticipated Program Activities:

In FY 2022, Highway Safety Research will continue research emphasis on preventing the destructive traffic safety behaviors of drug- and alcohol-impaired driving and distracted driving, and on protecting vulnerable road users with a focus on pedestrian safety. In these emphasis areas, NHTSA plans to conduct foundational research to understand the nature or scope of the problem; developmental research that is more applied and helps refine delivery of solutions; and a hybrid that combines research into the big ideas and potential ways to develop those into safety programs. One example is preparing for the next National Roadside Survey of Alcohol and Drug Use by Drivers, which NHTSA last conducted in 2013 and 2014, to determine the prevalence of drug and alcohol use among drivers on our roads. Another example is beginning a nationally representative survey of driver behaviors, attitudes, and awareness surrounding the issues of driver distraction and seat belt use, including exposure to and use of new technologies that may affect these behaviors. (NHTSA conducted its last distracted driving survey in 2015 and occupant protection (belt use) survey in 2016.) The important information obtained from efforts such as these inform the development of NHTSA's traffic safety programs, policies, and communications. In addition, Highway Safety Research will explore the effects of new technologies on behavioral safety, including continuing human factors research related to ADAS and ADS technologies. Highway Safety Research will continue to collaborate with NHTSA's Automated Driving Systems and Advanced Safety Technologies research programs to address human factor issues including behavioral adaptation and child-specific safety considerations related to ADS. Finally, Highway Safety Research is emphasizing equity in traffic safety as an overarching issue that is informing the development of new projects and the direction of existing research so as to increase our understanding of how these issues affect traffic safety. With this focus, traffic safety efforts that are deemed successful also will be ones that apply equitably.

DADSS technologies are undergoing rigorous field testing and systemic improvements as the Agency prepares to move from research to program development.

In 2022, NHTSA plans for four to six discrete BTSCRP projects to be selected that will result in applied research products that highway safety stakeholders will be able to use immediately upon the completion of the research. TRB will prepare requests for proposals and will assemble panels to select contractors to perform the work.

Expected Program Outcomes: Our expected outcome is research that contributes to the state of the knowledge through effective dissemination and to the way traffic safety is implemented at the State and local level. Not every project fits this path; however, measurable milestones for an ideal trajectory of a research project would be:

- 1-3 years post completion: Number of report downloads, press citations; demonstration project(s);
- 3-5 years post completion; Number of citations in literature; inclusion of strategy in Countermeasures that Work or an increase in the effectiveness rating of an associated countermeasure;
- 5+ years post completion: Citation in a grant program; inclusion in a standard or guideline; widespread (voluntary) adoption among States.

Success can also be measured by identifying and communicating what *doesn't* work to change behavior or enhance safety. This allows NHTSA to ensure that States use grant funds effectively.

The expected outcome of the DADSS research program is a system that meets reliability and other rigorous performance standards that could be easily deployed by a vehicle manufacturer. If fully deployed across the entire vehicle fleet, DADSS could prevent 7,000 deaths from impaired driving every year.

For each project under BTSCRP, practical applications for highway safety are envisioned from the start. The research findings, tools, and resources developed through this program are immediately put into action by States and local highway safety practitioners who use the outcomes to change policies and practices, resulting in lives saved.

Collaboration Partners: The Highway Safety Research program receives input from our program offices, regional offices, State highway safety offices, nongovernmental stakeholder organizations, Transportation Research Board standing committees, and a variety of other sources. Their input factors into our research planning process.

NHTSA collaborates with OST, FHWA, and FMCSA on specific topics of driver behavior. For example, NHTSA collaborates with FHWA and FMCSA on speed-related issues; the three

agencies have an intermodal speed team that meets periodically to share project information and occasionally to more formally collaborate on joint projects. NHTSA shares responsibility for pedestrian and bicyclist safety in partnership with FHWA. NHTSA works with the OST Office of Drug and Alcohol Policy and Compliance (ODAPC) to ensure the accuracy of alcohol testing performed for the over 60,000 employees who work in safety sensitive positions and to provide expert information on drug use by vehicle operators.

In addition, Highway Safety Research collaborates with other federal agencies such as ONDCP (Office of National Drug Control Policy), NIDA (National Institute on Drug Abuse), NIAAA (National Institute on Alcoholism and Alcohol Abuse), SAMHSA (Substance Abuse and Mental Health Services Administration), and CDC (Centers for Disease Control and Prevention) to leverage our resources and involve the public health community in our efforts to change behavior.

We also work with a variety of nongovernmental Organizations including the IACP (International Association of Chiefs of Police), NSA (National Sheriffs Association), NOBLE (National Organization of Black Law Enforcement officers), Safe Kids (child safety seats), NSC (the National Safety Council), MADD (Mothers Against Drunk and Drugged Driving), SADD (Students Against Destructive Decisions), and NETS (Network of Employers for Traffic Safety).

NHTSA works with the Automotive Coalition for Traffic Safety (ACTS) to execute the DADSS program. The ACTS membership includes the major automobile manufacturers. A stakeholder group that includes organizations such as the Insurance Institute for Highway Safety, MADD, the National Safety Council, and Safe Kids Worldwide provides strategic input on the program direction.

Lastly, BTSCRP, NHTSA, TRB, and the Governors Highway Safety Association (GHSA) work collaboratively to identify technology transfer targets based on research projects of mutual interest.

FY 2023 RD&T Programs
Office of Vehicle Safety Research (VSR)

Program Name: Vehicle Electronics and Cybersecurity

Program Description: With the increasing proliferation of computer-based control systems, software, connectivity, and onboard data communication networks, modern vehicles need to consider additional failure modes, vulnerabilities, and threats. Additionally, connectivity and safety technologies that can intervene to assist drivers with control of their vehicle could also raise the cybersecurity stakes, and without proactive measures taken across the vehicle lifecycle, risks could rise accordingly. Methodical identification of potential issues and proactive management of increased risks related to advanced electronic and software-controlled systems are essential to designing vehicle architectures that will respond safely even when there are electronic system failures, software errors, or malicious software attacks. In FY 2023, the Vehicle Electronics and Cybersecurity research program will continue coverage of two major research areas: *Electronics Functional Safety* and *Vehicle Cybersecurity*.

Program Objectives: Program objectives support enhanced reliability and resiliency of vehicle electronics, software, and related vehicle control systems to both mitigate safety risks associated with failure and/or cybersecurity compromise of such systems, as well as safeguarding against public concerns that may pose public acceptance barriers for proven safety technologies and emerging ADS. The program seeks to support improvements in the cybersecurity posture of motor vehicles, and understand and promote contemporary methods in software development, testing practices, and requirements management to address underlying hazards and risks across the vehicle life cycle. These activities include close collaboration with industry to promote a strong cybersecurity risk management culture and associated organizational and systems engineering processes.

Anticipated Program Activities: *Functional Safety.* For FY 2023, the research scope continues to extend to new capabilities ADS developers are introducing including using wireless communications to facilitate remote manual operation (or intervention) of the vehicle (i.e., teleoperations). Research will continue to characterize functional safety requirements for key heavy vehicle support systems, such as electronic controlled braking and electronic power steering systems for heavy vehicles.

Cybersecurity. In FY 2023, VSR will conduct targeted research on how the auto industry addresses the full lifecycle of cybersecurity risks including identifying, protecting, detecting, responding, and recovering from cybersecurity threats. Further, NHTSA's research will support

the interpretation and application of automotive-focused cybersecurity standards by vehicle manufacturers and suppliers.

Program Name: Advanced Safety Technology

Program Description: Advanced Safety Technology research focuses on both traditional motor vehicle crash avoidance technologies (i.e., tires, brakes, lighting) and ADAS features (collectively SAE driving automation Levels 0-2) that assist drivers in avoiding crashes. The research program covers passenger vehicles, medium and large trucks, buses, motorcycles, and vulnerable road users. Research will seek to reduce motor vehicle fatalities through a focus on target technologies that have the potential to reduce high frequency crashes.

Program Objectives: The principle objective of this program is to lead national safety research to advance and accelerate the responsible deployment of ADAS across the U.S. automotive fleet. This program will continue to focus on harnessing emerging technologies and innovative safety systems that directly map to crashes. Research is conducted with the objectives of attaining a comprehensive understanding of all ADAS-enabling technologies and trends, such as underlying sensor technologies and strategies. Research also encompasses quantifying ADAS performance, capabilities, limitations, effectiveness, and risks for all classes of vehicles and all roadway users.

Anticipated Program Activities: *ADAS Innovation and Deployment*: Innovative technologies considered for research include active safety systems, such as cross-traffic alert systems, that have potential to address some types of intersection crashes and opposite direction (head-on) collision avoidance systems.

Safety Performance Assessment of ADAS Technologies: Safety performance assessments of ADAS technologies deployed in new production vehicles will continue in FY 2023 and will include computer simulations, closed-course testing, and/or naturalistic roadway evaluations.

*ADAS Human-Machine Interface (HMI)***:** In FY 2023, NHTSA's research program will continue to examine ADS-related HMI effectiveness and design issues and may include evaluation of emerging in-vehicle HMI technologies, such as gesture-based inputs, and augmented reality displays, as well as behavioral adaptation to ADAS.

Driver Engagement and ADAS: In FY 2023, SAE Level 2 driving automation research will continue to focus on examining a driver's readiness to resume control when an ADAS issues a request to intervene that is critical to safety. Human factor challenges and benefits for these new technologies will continue to be evaluated. Research into the effectiveness of driver monitoring system strategies at mitigating driver distraction will continue.

Heavy Duty Safety Technologies: In FY 2023, VSR will continue research to support agency regulatory initiatives aimed at automatic emergency braking, as well as research into the

effectiveness of lane departure warning and SAE driving automation Level 2 features for heavy vehicles.

Program Name: Automated Driving Systems (ADS)

Program Description: Vehicles equipped with ADS remain in the development and testing phase. While limited ride-hailing deployments are beginning to emerge and are open to the public, such deployments are highly monitored demonstrations focused on testing and refinement of the technology. A vehicle equipped with ADS, when engaged, can perform the full driving task without an expectation of an engaged driver. ADS-equipped vehicles hold the potential to improve safety beyond levels achievable with ADAS alone. As a result, ADS research continues to be an important emphasis area for NHTSA.

Program Objectives: This program objectives of the ADS research area include the following tracks primarily focused on supporting the safe deployment of ADS-equipped vehicles:

- Updates to FMVSSs to accommodate innovative ADS-equipped vehicle designs
- ADS safety performance research to develop and apply tools and methods to assess the safe performance of ADS-equipped vehicles
- Human factors research to support safe and effective communications between ADS-equipped vehicles, passengers, and other road users.
- Crashworthiness research to address restraint designs for new seating arrangements and other novel design elements anticipated with ADS-equipped vehicles.

Anticipated Program Activities:

Research on ADS safety performance: In FY 2023, research will continue to explore methods, metrics, and tools for assessing the safety of ADS-equipped vehicles. These include modeling and simulation, closed-course testing, and on-road naturalistic testing. The research will also include development of a common "language" for describing ADS test scenarios, and methods for selecting specific test scenarios to efficiently test ADS capabilities or attributes of interest. Additional research will focus on evaluating the application of leading-edge analytical methods that leverage operational data (or results) from various testing venues to develop safety performance metrics. Research will continue related to ADS-equipped vehicle subsystems, including methods for examining performance of ADS perception and execution systems. Methods to assess pedestrian recognition performance across a diverse population of road users will be utilized to encourage equity and inclusiveness during the design process. Research will also evaluate a vehicle's ability to accurately follow path-planning instructions from the ADS's decision support system.

Crashworthiness of ADS-equipped vehicles: In FY 2023, research will apply Human Body Models (HBM) to evaluate occupant restraints for the range of seating conditions expected in new ADS designs. In FY 2023, research will refine understanding of human response and injury metrics for various alternative seating conditions. Anthropomorphic test devices will be adapted for use in forward- and rear-facing reclined seating configurations. The Agency will also

continue to develop best practices for safe interaction of non-occupied ADS-equipped vehicles with existing vehicles, roadside hardware, pedestrians, cyclists, and motorcyclists.

Human factors research to support safe and effective communications between ADS-equipped vehicles, passengers, and other road users: ADS-equipped vehicles and ADS-DV designs will influence humans' interactions with vehicles. In 2023, the Agency will continue to investigate emerging ADS human factors topical areas (e.g., external HMI, driver-vehicle interface, communication of intent, etc.) and to research different methods for transferring knowledge from the ADS to the driver/operator to improve situation awareness. Since in some situations, it may be necessary for a remote operator to take over control of an ADS-DV, the Agency will continue to execute research to better understand the human factors considerations associated with remote operation.

Program Name: Crashworthiness

Program Description: Crashworthiness research focuses on vehicle safety countermeasures to reduce the number of fatalities and serious injuries that result from motor vehicle crashes in the United States each year. This research program is responsible for developing and upgrading test procedures for the evaluation of motor vehicle safety, and for developing evaluation tools (e.g., crash test dummies and human body computer models) and appropriate injury metrics. Crashworthiness research encompasses new and improved vehicle designs, equipment and safety countermeasures; biomechanics and injury causation; real-world field data collection and analysis of serious injury cases; and computer modeling based research all aimed at enhancing outcomes for motor vehicle occupants and vulnerable road users. The program directly supports the Department's goal of reducing transportation-related fatalities and serious injuries across the transportation system.

Program Objectives: The purpose of the Crashworthiness research program is to investigate the problems of vehicle crash safety and associated factors (e.g., vehicle design, human response/injury tolerance) that contribute to serious injuries and fatalities. The near-term goal is to identify fatality and injury trends and to enhance safety requirements and best practices to improve crash outcomes for vehicle occupants and vulnerable road users. This program supports the Department's critical research priority to improve safety.

Biomechanics research makes significant contributions to safety by developing publicly available data, tools, performance measures, and procedures that NHTSA and industry use, both to understand how vehicle occupants and vulnerable road users are injured in crashes and for assessment of vehicle safety countermeasures. Biomechanics research also works with trauma centers to understand the detailed nature of injuries. The causes of these injuries are evaluated through laboratory test programs and computer simulations. The new knowledge that is gained through injury research is applied towards the development, evaluation and refinement of crash test dummies and associated injury measures as well as towards the enhancement of computer models (e.g., human body models). These tools are then utilized to support vehicle safety countermeasure development for occupants of all ages, size and gender.

In 2023, Biomechanics research will continue to focus on completing the development, evaluation, and documentation associated with advanced testing and simulation tools (ATDs, human body models). The application of these enhanced tools will increase both the Agency's and industry's ability to assess occupant protection safety in frontal, side, oblique, and rear impact crash modes. Included in these efforts is research supporting the completion of testing, evaluation, and documentation associated with a new small female frontal impact crash test dummy (Test Device for Human Occupant Restraint or THOR 5th percentile). Related to both the THOR 5th and human body models, there will continue to be an emphasis on researching differences in injury risk between males and females. Research supporting the development and

documentation of the THOR 5th will continue to include efforts to develop and utilize female-specific response and injury data for use in developing injury criteria. Research concerning human body models will include the development and application of a 50th percentile female.

Additionally, the program focuses on vulnerable populations (e.g., pedestrians, children, and older occupants). Pedestrian research will focus on completing and evaluating test tools to assess vehicle countermeasures addressing pedestrian safety. Older occupant research focuses on evaluating leading injury mechanisms for older occupants: brain injuries (subdural hematoma) and thorax injuries.

Safety Systems research is responsible for evaluating new crash safety concerns and for developing safety concepts, test procedures, and performance measures. Safety Systems research examines existing designs, new and improved vehicle designs, safety countermeasures, materials, and equipment to enhance safety for all occupants in the event of a crash. In 2023, Safety Systems research will continue to use the tools and criteria developed through Biomechanics research to develop strategies for achieving equitable safety for occupants with diverse body sizes and shapes. Child safety will continue to be a major focus area, with research toward improving the frontal crash performance of child restraints, including larger children in booster seats. Occupant safety in front and side crashes will be assessed using new, advanced crash test dummies. Frontal crash protection will also focus on improving safety for rear seat occupants, occupant injury and seat back strength in rear impacts will also be evaluated.

The Crashworthiness research program supports the entire private sector rather than benefitting any single company. Research on evolving crash injury mechanisms and the development of safety assessment tools is intended for widespread use in automotive design.

Anticipated Program Activities: Safety Systems will support research to evaluate new test dummies and injury metrics in current and future crash conditions, develop or revise test procedures, and assess the effectiveness of occupant protection systems. Biomechanics will fund research to develop tools (crash test dummies, mathematical models) and injury metrics that can be applied towards the assessment of advanced vehicle safety countermeasures.

Program Name: Alternative Fuels Vehicle Safety

Program Description: NHTSA is gathering information from all sources regarding the safety of emerging transportation fuels including battery, stored gas, and fuel cell technologies. This advanced knowledge is helping to direct the research projects, refine safety assessments, and develop performance tests. NHTSA is partnering with industry and other federal agencies to develop appropriate safety performance considerations for these alternative fuel vehicles. These technologies should all involve research between the DOE national laboratories, the automotive original equipment manufacturers (OEMs) and their suppliers. The planned research will also apply past research on charging safety to new battery designs and consider both commercial and residential applications.

Program Objectives: NHTSA has worked with the Department of Homeland Security to document standards and best practices for emergency medical responders. This study will be extended to research capabilities to address difficulties EMS responders encountered in responding to battery electric vehicle crashes, fires and stranded energy situations. NHTSA will continue to partner with industry, standards organizations, and other Federal agencies to develop appropriate safety performance for new alternative fuel vehicles.

Anticipated Program Activities: NHTSA will continue to collaborate with other agencies on funding and other research programs to develop and investigate best practices for vehicle safety for these emerging systems. The program meets the annual funding Appropriations Act's requirement to conduct alternate fuels vehicle safety research.

Program Name: Vehicle Research and Test Center (VRTC)

Program Description: VRTC is NHTSA's in-house applied research, development, test, and evaluation laboratory located in East Liberty, Ohio. Research and testing activities conducted at VRTC support Agency decisions and actions with respect to new vehicle systems and issues, Agency consumer information programs, test dummy development, injury criteria development, advanced research into cutting-edge technologies, and safety issues that require quick reaction, including defect investigations. The full range of testing and research capabilities available to NHTSA at VRTC allows the Agency to maximize its testing capabilities to more rapidly study emerging safety issues and more quickly provide benefits to the American public.

Program Objectives: VRTC supports a broad range of critical safety areas including:

- Crash avoidance research (light and heavy vehicles), including support for updating existing Agency safety tests and research of new emerging ADAS technologies. This program area also examines human factors related to vehicle system and technology use and supports development of foundational tests, methods, and safety metrics to enable future Agency evaluation and policy decisions for emerging ADS technologies and includes human factors research to ensure that advanced technologies are used by drivers in ways that successfully reduce crashes;
- Crashworthiness research, including support for updating existing Agency tests and test procedures as well as research on new occupant protection topics to enable deployment of innovative new technologies;
- Biomechanics research, including adapting and upgrading existing tools (crash test dummies) for compatibility with new technologies such as ADS;
- Lab and in-field support for safety defects investigations; and
- Research into complex areas such as ADS and cybersecurity to support development of safety approaches, methods, and tests.

Research in these areas directly supports the Department's goal to reduce transportation related fatalities and serious injuries across the transportation system. This aligns with NHTSA's mission and the Department's goals to deploy new and innovative technologies.

Anticipated Program Activities:
VRTC will continue to support a broad range of critical safety areas including advanced safety technologies research to evaluate new technologies that help drivers prevent crashes, crashworthiness research to improve occupant protection in crashes, biomechanics research to develop, evaluate, maintain, and improve the Agency's vehicle crash test dummies, lab and in-field support for safety defects investigations, and research into complex new areas such as ADS-equipped vehicles, electric-powered vehicles, and cybersecurity. The FY 2023 funding will be used to procure equipment needed to maintain a well-equipped and dedicated center to test, monitor, and investigate these and other emerging safety issues.

FY 23 Office of Behavioral Safety Research (BSR)

Program Name: Highway Safety Research

Program Description: Highway Safety Research provides the scientific basis for the development of effective behavioral countermeasures to reduce the occurrence and severity of traffic crashes. Highway Safety Research also evaluates the effectiveness of programs to reduce fatalities and injuries on our highways, which is critical to assist States in allocating resources effectively and achieving national performance targets. In addition, Highway Safety Research monitors and measures both safe and unsafe driving behaviors to track progress and identify emerging safety problems.

NHTSA's Highway Safety Research program supports the Department's safety efforts through behavioral research, demonstrations, technical assistance, and national leadership activities emphasizing alcohol- and drug-impaired driving countermeasures, occupant protection, distraction, traffic law enforcement, emergency medical and trauma care systems, driver licensing, State and community traffic safety program evaluations, motorcycle rider safety, pedestrian and bicyclist safety, pupil transportation, and young and older driver safety programs.

Highway Safety Research also funds the DADSS project. Despite progress over the past three decades, drunk driving claims approximately 10,000 lives each year. The DADSS project is researching a first-of-its-kind technology that holds the greatest potential we have seen to reverse this trend. The technology is being designed to automatically detect when a driver is intoxicated with a BAC at or above 0.08% — the legal limit in all 50 states except Utah — and prevent the car from moving. Once it has met rigorous performance standards, it will be voluntarily offered as a safety option in new vehicles, similar to automatic braking, lane departure warning and other advanced driver assist vehicle technologies.

Lastly, Highway Safety Research funds the BTSCRP. BTSCRP, which is administered by the Transportation Research Board, is a forum for coordinated and collaborative research to address issues integral traffic safety professionals at all levels of government and the private sector. BTSCRP provides practical, ready-to-implement solutions to save lives, prevent injuries, and reduce costs of road traffic crashes associated with unsafe behaviors.

BTSCRP products are developed in response to problems faced by traffic safety stakeholders. Emphasis areas are alcohol-impaired driving, autonomous vehicles, bicyclists and pedestrians, child passenger safety, distracted driving, drowsy driving, drug-impaired driving, law enforcement, mature drivers, motorcyclist safety, seat belts, speed and safety cameras, speeding and aggressive driving, teen driver safety, and traffic records. BTSCRP will produce a series of

research products that traffic safety stakeholders, government agencies, and other interested parties will be able to quickly use or implement in their traffic safety practices.

Program Objectives:

The research will support five overlapping strategic goals:

- Preventing destructive traffic safety behaviors;
- Encouraging positive traffic safety behaviors;
- Leveraging public safety to improve traffic safety;
- Protecting vulnerable road users; and,
- Exploring advanced technologies to address traffic safety issues.

Anticipated Program Activities:

In FY 2023, NHTSA will decide to emphasize various areas based upon problem identification and research needs although continued efforts are expected in preventing drug-impaired driving and the effects of new technologies on behavioral safety. In these areas, NHTSA plans to conduct foundational research to understand the nature or scope of the problem; developmental research that helps refine delivery of solutions; and a hybrid that combines research into the big ideas and potential ways to develop those into safety programs.

Human factors research, particularly related to ADAS and ADS technologies, will likely remain a focus. Highway Safety Research will continue to collaborate with NHTSA's Automated Driving Systems and Advanced Safety Technologies research programs to address human factor issues including behavioral adaptation and child-specific safety considerations related to ADS.

DADSS technologies will continue undergoing rigorous field testing and systemic improvements as the Agency prepares to move from research to program development.

In FY 2023, NHTSA plans for four to six discrete BTSCRP projects to be selected that will result in applied research products that highway safety stakeholders will be able to use immediately upon the completion of the research. TRB will prepare requests for proposals and will assemble panels to select contractors to perform the work.