ANNUAL REPORT

THE NATIONAL ADVANCED DRIVING SIMULATOR 2019

THE UNIVERSITY OF IOWA | College of Engineering

Safety is what we live for

For more than 20 years, the National Advanced Driving Simulator at the University of Iowa has sought to improve safety on our nation's roadways by researching the connection between drivers, motor vehicles, and road users. Founded after winning a highly-competitive National Science Foundation grant, NADS is an engineering wonder with the most advanced technologies available to conduct driving safety research. This work ranges from investigating distraction, impairment, advanced vehicle technologies, training programs, and much more.

We're committed to studying and improving safety for all types of road users by collaborating closely with bicycling and pedestrian labs on-campus, as well as partner sites across the world. We're leading the way in rural roadway research of automated vehicle technologies. We're exploring unexpected partnerships and developing unique programs with the arts. And we're investing in the future of transportation safety by participating in and organizing STEM events for tomorrow's science, technology, engineering, and math leaders.

At NADS and the UI, we're proud to be driving excellence and transforming the future.

For more information, visit
www.nads-sc.uiowa.edu


THE UNIVERSITY OF IOWA
THE NATIONAL ADVANCED DRIVING SIMULATOR
NHTSA
MyCarDoesWhat.org
Know More. Drive Safer.

Making roads safer today by planning for tomorrow

It takes a solid foundation to develop a high-quality research program that people and organizations worldwide can trust. We are proud to have built that foundation and reputation here at the University of Iowa. Last year, we celebrated the National Advanced Driving Simulator's 20th anniversary; however, driving safety research began taking place here decades before NADS even opened its doors, making the UI one of the top transportation research centers in the field.

For the last few decades, we've contributed to a better understanding of how humans interact with vehicles. In fact, many of the technologies in today's vehicles came through the UI as part of their research and development and safety testing. A few of these everyday technologies include anti-lock braking systems, electronic stability control, adaptive cruise control, and forward collision warning.

We rely on our team of experts at NADS and faculty across all colleges at the UI to conduct our wide array of research. Today, we're focusing our resources on critically important work such as studying distracted and impaired driving, improving transportation for mobility-challenged populations, and making rural roadways safer for everyone. A key area for us is ensuring that the next generation of more highly automated vehicles operate as safely as possible on public roads.

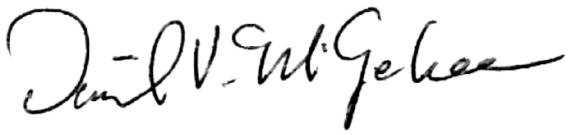
This year marks an exciting development for the UI and NADS. In September, the USDOT announced the UI as a recipient of a prestigious Automated Driving Systems (ADS) Demonstration Grant. Our ADS for Rural America demonstration project will utilize a custom, mobility-friendly vehicle with advanced technologies to gather publicly-available data for analysis. The data collected will help identify challenges, opportunities, and insights relevant for USDOT safety and rulemaking priorities. In this work, we seek to improve safety on our nation's roadways, address disparities, and demonstrate how new technologies can enhance mobility for all, particularly aging populations in rural communities.

Part of planning for the safety of tomorrow's roadways also includes training future transportation researchers. We're proud to build on our commitment to the future of transportation safety by increasingly hosting and participating in STEM events across Iowa. Additionally, we're training and employing UI undergraduate, graduate, PhD, and post-doc students as they explore their interests and work in roadway safety research.

While we're taking on new projects and growing our research portfolio, we are still true to our roots. Making our roadways safer for everyone will always be at the center of everything we do.

Our past has been nothing short of remarkable. We are proud of the outstanding accomplishments that have made NADS the premier transportation safety research center that it is today. Our interdisciplinary collaborations across virtually every college at the UI makes us unique in global research. And we're always looking for new partnerships in unexpected places, like we did with our 2019 *Crash Dance: There Are No Accidents* collaboration with the UI Department of Dance.

While we're proud of what we've done, we're also tremendously excited about our future as we expand our on-road automated vehicles research, data collection and sharing, impaired driving work, efforts to benefit mobility-challenged populations, and much more.



Daniel V. McGehee
Director, National Advanced Driving Simulator
Associate Professor
Industrial & Systems Engineering
Emergency Medicine
Public Health
Public Policy

Fiscal Year 2019 Highlights:

$7 million
USDOT Automated Driving System Demonstration Grant award

4,000
takeover events orchestrated and recorded during NADS' first on-road automated vehicle study

More than 100
years of expertise amongst our driving safety researchers

10,000
trips taken by the NADS-1 since 2007


Research Vehicle
THE UNIVERSITY OF IOWA
Iowa
AU2M8
OFFICIAL

From project start to finish, we develop high-quality research with trusted results

Experts

Our in-house team of experts, adjunct faculty, and network of collaborators have experience in developing a wide range of research plans suitable to meet our partners' needs in areas like:

- Human factors
- Health and pharmaceutical evaluation
- Advanced technologies
- Testing against industry standards
- Naturalistic studies

Participants

There are currently more than **10,000** individuals in our National Advanced Driving Simulator participant registry. This large base means we can match nearly any study with the right participants to meet partners' needs.

Unique capabilities

Our team of qualified professionals has experience leading studies in a wide and unique range of topics, including:

- Cannabis (with and without alcohol)
- Pharmaceuticals
- Medical devices
- Parkinson's
- Novice drivers
- Advanced technologies
- Machine-learning
- Drowsiness mitigation
- And much more

More than **40** faculty, staff, and students conduct NADS-related research on a daily basis

Facilities and tools

Our one-of-a-kind facilities and tools help us to conduct right-sized, cost-effective research for a wide range of projects.

- NADS-1 high-fidelity simulator
- NADS-2 fixed-base simulator
- Portable, customizable miniSims in a variety of configurations
- Instrumented vehicles

To sign-up to become a potential study participant, visit: **www.drivingstudies.com**


DIRECT LIFT

Self-sustained, not self-centered

Independent lab, trusted results

The National Advanced Driving Simulator is an independent, self-sustained transportation safety research center at the University of Iowa. External contracts and grants, sponsored by government and industry, fund all staff, equipment, facility, and faculty and student involvement. NADS has established a reputation for being independent and letting only the data that we collect influence our findings. We're here to give our partners results they can trust.

We work for our partners, not for profit

Being a non-profit enables us to put a priority on delivering a high value to our public and private sector partners. All of the funding we receive for our studies goes directly toward the work we do to improve roadway and driving safety for everyone.

Case study: The NADS miniSim™

A prime example of our work to help partners get the most for their money is the NADS miniSim. A portable, high-performance driving simulator used for research, development, clinical, and training applications, the miniSim harnesses the technology found in the NADS-1 into a smaller footprint at a lower cost.

The vision behind our world-renowned miniSim was to create an affordable and accessible solution that would allow users to cost effectively fulfill their research and development goals. The miniSim is built on a researcher-driven platform, one that provides a large collection of proven scenarios for investigating distraction, impairment, vehicle safety, cognition issues, and much more. Using a miniSim also provides access to an international network of researchers who are using the same core simulation technology, facilitating the sharing of scenarios, research, and ideas in a secure environment.

More than simulation

What's in a name?

Our name may be the National Advanced Driving Simulator, but we're about more than just simulation. Our in-house experts conduct a variety of studies using a combination of research methods, from high-fidelity simulation to controlled on-road studies to naturalistic data collection. As the world of transportation evolves, so do we. Every day we work with our partners to develop new methods to better understand and tackle important problems. At NADS, we're innovators and experts in driving simulation...and much, much more.

Expanding our on-road research

Our on-road research vehicles are outfitted with a variety of advanced driver assistance systems. Some of these are original from the manufacturer while others have been developed and installed in-house by our own staff and students. Moving forward, we're utilizing these vehicles and technologies in on-road research more and more each day. For instance, in early 2019, we conducted our first controlled driving study on a public roadway. During this industry-sponsored project, we studied driver takeover from automation using our Tesla research vehicle. This year, we're expanding that study to a private, closed test track to evaluate takeovers and driver response to unexpected events in automation.

Tackling big data

We'll take on big data with our upcoming on-road research project, Automated Driving Systems (ADS) for Rural America. This study will collect a large set of data (210TB) on how our mobility-friendly vehicle is able to navigate rural Iowa roads at varying levels of automation in different seasonal, roadway, and lighting conditions. This data will help identify what data sources will be needed to enable higher levels of automation in rural communities so that the nation can better prepare itself to support automated vehicles. Data collected through ADS for Rural America will also help identify traffic and roadway scenarios that need to be addressed to support the safe deployment of automated vehicles. Our data will be publicly available for a minimum of five years after the project's conclusion to help researchers and others across the country make our roadways safer for everyone.

Testing technologies to improve safety

At NADS, we're always testing how the safety of existing technologies can be improved or using them in new ways. With our recent hazard alerting demonstration, we custom built instrumentation for slow-moving vehicles like tractors and school buses that often travel our rural roadways. This instrumentation transmits a slow-moving vehicle's position, speed, and heading, plus video and warning light status, via a cellular network. The transmitted data enables our 2018 Lincoln MKZ automated vehicle to alert a safety driver of these slow-moving or stopped vehicles along a route, thus providing advanced warning to avoid the hazard. This technology is particularly important when encountering many of the unique challenges that rural roadways pose, like sharp or blind curves, steep hills, and hidden field entrances.


SCH


RESEARCH VEHICLE
THE UNIVERSITY OF IOWA
AUTOMATED VEHICLE RESEARCH

ADS for Rural America

Rural roads and advanced vehicle technologies

Nationwide, rural communities and roadways are disproportionately affected by traffic safety issues. Meanwhile, rural roads are underrepresented in ADS research today. Additionally, a relatively large and growing portion of rural and small-town residents are older Americans. As our nation's population significantly ages over the next few decades and Americans continue their desire to "age in place" (living in their own home regardless of age, income, or ability level), increased rural mobility options will be needed to maintain and, ideally, improve safety on these roadways.

USDOT award

In 2019, the USDOT announced the University of Iowa and its partners as a recipient of a $7 million Automated Driving Systems (ADS) Demonstration Grant. The UI's ADS for Rural America project is a 2.5-year demonstration that will utilize a custom, mobility-friendly vehicle with advanced technologies to gather publicly-available data for analysis. Data collected will help identify challenges, opportunities, and insights relevant for USDOT safety and rulemaking priorities. At the same time, the project will focus on studying ADS applications for aging, transportation-challenged rural populations.

Project goals

ADS for Rural America is a complex project centered around a few key goals:

- **Improve safety** on our nation's roadway system by beginning to lay the groundwork for the safe integration of ADS
- Work to **address disparities** in the US roadway system by focusing demonstrations and ADS data gathering in rural areas
- Demonstrate how ADS can be used to **enhance mobility** for transportation-challenged populations such as the aging populations in our rural communities

By 2030, 1 in every 5 Americans will be of retirement age. By 2035, for the first time in US history, adults 65 and older will outnumber children under the age of 18, with the gap continuing to widen.

- US Census Bureau (2018) and US Department of Health and Human Services (2018)

KEY PROJECT PARTNERS

The University of Iowa | Iowa State University | Iowa DOT Getting You There | Autonomous Tuff | Mandli Communications


Iowa
10406
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Everyone deserves safer roads

Only 19% of Americans live in places designated as rural. But, every year, about HALF of traffic fatalities happen on rural roads.

- NHTSA Traffic Safety Facts

Rural roads pose unique challenges

Rural areas are disproportionately affected by traffic injuries and fatalities. Farms are increasing in size, often by acquisition of non-contiguous land, and there's a trend towards greater management of farms by renters/leasers. The US is experiencing continuing urbanization of traditionally rural areas. People are more mobile than ever before. All of these factors, and many more, have led to a substantial increase in the mix of agricultural equipment with faster-moving vehicles on rural roadways.

Drivers unfamiliar with rural roads and the unique challenges they pose may not recognize what they're approaching or may not be expecting slow-moving or stopped farm equipment or other vehicles, like school buses. Additionally, rural crashes are more likely to occur at higher speeds and further away from emergency care facilities.

We recognize the importance of studying new ideas and technologies on our rural roadways to improve safety for everyone. It's because we travel these roads every day, and so do the people most important to us.

Hazard alerting project

We've spent the last year collaborating with the Iowa DOT to research, develop, and demonstrate hazard alerting of slow-moving rural tractors and school buses in our cloud-connected vehicle. Our researchers have outfitted test vehicles, two school buses and tractor, with cellular technology that tracks location and warning light status and relays that information, plus video, to our cloud-connected server. If a school bus is, for example, stopped just over the crest of a hill, the driver may not see or expect it. But with a hazard alert from the cloud-connected research vehicle, the driver is notified of its presence. The technology is so precise it can even tell the driver if the school bus' stop sign arm is extended, letting them know that children may be crossing the roadway.

Where do we go from here?

We've demonstrated that the technology can work. Now, where do we go from here? We'll continue to refine our hazard alerting system and expand our demonstrations. We'll also work to incorporate the technology into other rural roadway projects, like our ADS for Rural America demonstration grant.

While fully functional automated vehicles are far into our future, we're proud to be ahead of the curve, developing and demonstrating technologies that can help drivers operate their vehicles more safely today.

Rural roads pose unique challenges

- High speeds
- Sharp curves
- Steep grades
- Limited sight distances
- Smaller widths
- Soft or limited shoulders
- Ditches, culverts, utility poles, and trees closer to the road than in urban areas
- Hidden field entrances
- Loose gravel
- Animals
- Inadequate slow-moving vehicle signage

Learn more and watch a demo video: **https://uiowa.edu/stories/iowa-researchers-prepare-rural-roads-future**

A miniSim that gets BIG results

With the miniSim, we work for you

The miniSim™ is high-performance driving simulator software designed for research, development, clinical, and training applications. Recognized as a world leader in modern, sophisticated, and effectively-priced driving simulators, the miniSim is based on decades of research and development at the National Advanced Driving Simulator.

Customizable

While there are a number of standard miniSims available (desktop, simplified-cab, quarter-cab, and half-cab), miniSim can be engineered to meet any customer's specific requirements. This includes developing custom cabs, display systems, driving environments, geospecific locations, scenario models, user interfaces, active safety subsystems, and more.

Keeping pace with the future

We've been busier than ever at miniSim, but that doesn't mean we've lost sight of what's important. We're continuing to keep pace with the technologies, systems, and scenarios our users need to conduct their work. Recently, the miniSim software received major upgrades. In addition to previously available enhanced vehicle automation and transfer of control, miniSims now have lane-keeping assist and new instrumented infotainment and haptic seat options. Steering upgrades have also been completed to support active safety and automation systems, in order to make the miniSim as realistic of a driving experience as possible.

For more information, visit
www.nads-sc.uiowa.edu/minisim

We're helping make transportation safer and more accessible for all

Determining mobility needs for aging populations

Baby boomers are reshaping America's older population. Additionally, the vast majority of seniors want to stay in their homes. Recently, the AARP Public Policy Institute found that 87% of Americans 65 and older desire to "age in place," continuing to live in their own home safely, independently, and comfortably, regardless of age, income, or ability level. And it's not just about medical appointments; mobility-challenged seniors may also face social isolation, depression, and lack of access to healthy foods. More suitable mobility options are needed today to allow aging populations to keep their independence and maintain a high quality of life.

To begin to understand the transportation needs and challenges faced by mobility-impaired adults living in rural America, NADS recently collaborated with an industry partner to develop and conduct a survey focusing on these issues. The survey, sent to adults 65 and older living in rural Iowa, included questions regarding health, lifestyle, and acceptance of and attitudes toward different types of transportation options, as well as existing challenges and needs not being met. Attitudes associated with more advanced transportation options that may be available in the future were also examined.

The survey found that the vast majority of rural elderly still own a vehicle, have a drivers' license, and drive themselves for most trips they take. This was true even for those with mobility issues, such as the need to use a cane, walker, or wheelchair. There was a desire for more trips that involved socializing, especially for those 85 and older. Surprisingly, there was a high degree of interest in automated vehicles and technologies that could help seniors be more mobile.

Moving forward, NADS continues to be committed to working with seniors to identify and address transportation issues and opportunities, particularly for mobility-challenged seniors in rural areas.

Aerobic exercise in Parkinson's disease

Parkinson's disease (PD) is an incurable brain illness that afflicts more than one million Americans. PD places an unbearable burden on the individual due to progressive impairment of movement and cognitive function. As a result, patients lose critical abilities such as driving. Although drugs and surgery help movement problems, their benefits are temporary, do not prevent dementia, and may cause side effects.

Animal and preliminary human studies on aerobic exercise show promising results in helping address a broad spectrum of PD symptoms. However, due to limited and inconsistent research results, long-term effects of aerobic exercise on brain health and clinical features in PD are unknown.

This year, NADS is collaborating with researchers at UI Hospitals & Clinics on a clinical trial funded by the Iowa City VA Health Care System to test the long-term effects of aerobic exercise on brain tissue, movement, cognition, mood, sleep, fatigue, quality of life, and driving in individuals with PD. NADS will provide one of our instrumented research vehicles, safety personnel for study drives, and manage and maintain video data.

87% of Americans 65 and over want to "age in place," continuing to live in their own home safely, independently, and comfortably.

- AARP Public Policy Institute (2014)

Looking beyond bioptic telescopes

For the past 40 years, bioptic telescopes have been the most frequently used option to allow drivers with visual impairments to maintain driving independence. However, bioptic telescopes require a switching of visual attention, potentially leading to driver distraction and inattention blindness. Additionally, the visual field restriction of such devices reduces overall situation awareness by narrowing the driver's attention.

Wayfinding has advanced dramatically with modern technologies like GPS and advanced driver assistance systems. Audio options allow drivers to keep their eyes and attention on the road and traffic around them.

More research is needed on modern, less distracting alternatives like these to bioptic telescopes. In working toward better understanding driver performance of those with visual impairments, this year NADS, Visual Sciences at the University of Iowa Hospitals and Clinics, and the UI Department of Ophthalmology began conducting a research study evaluating on-the-road driving performance of trained individuals using bioptic telescopes versus matched individuals using a talking GPS for wayfinding in unfamiliar driving environments. This study builds on a strong foundation of research from our experienced UI team.

Bioptic telescope - A distance vision-enhancing device that magnifies between two and six times, used by those with impaired vision.

Connected simulation

Why connect simulators?

The expectations, anticipations, and responses of drivers and non-motorized travelers to the behaviors of other road users are critical to road safety. To study these interactions, simulators must bring visible representations of people into the simulated world so that drivers, pedestrians, and bicyclists can see the gestures, gaze, and actions of other road users. Pedestrian and bicycle simulators have been used to understand decision-making by vulnerable road users in traffic. Moreover, driving simulation studies have provided valuable insights for new vehicle designs and on the behavior of drivers.

However, the lack of realistic and dynamic interactions between drivers and vulnerable road users is a glaring limitation of these simulators. Today, in almost all simulation research, it's just one participant driving, walking, or riding a bike in a computer-controlled environment.

Connected simulation technology offers enormous potential to study the interactions amongst road users and assess the impact of new technologies on safety and mobility.

Exploratory advanced research

The Federal Highway Administration (FHWA) Exploratory Advanced Research program is intended to spur innovation and focus on higher risk and higher pay-off research. Projects funded under the program could lead to transformational changes and revolutionary advances in US transportation. The University of Iowa was awarded a $1.8 million grant and began work in 2017 on a project to connect simulators and avatars from the National Advanced Driving Simulator, Hank Virtual Environments Laboratory, and Visual Intelligence Laboratory.

Connecting simulators

To investigate the interactions between drivers and vulnerable road users, it's important to capture the motions of participants as they interact with each other. This requires the introduction of avatars: graphically generated human models that mimic participant motions. But avatar generation is still a relatively immature area. Currently, the team is working to develop avatar technology to visually represent participant glances and movements, as well as connect the various simulators.

Next steps

Next steps in this significant undertaking include developing scenarios and determining how to get the participants/avatars to interact when they can move freely within the virtual world.

Pedestrian fatalities increased by 9% in 2016 and reached their highest number since 1990.

- NHTSA Traffic Safety Facts (2017)


Giro


The National Advanced Driving Simulator
The University of Iowa

Preparing Iowa for the future of transportation

Keep up with the ATC at:
http://iowadrivingav.org

The future of roadway safety

What will a future with automated vehicles look like? Advanced driver assistance system technologies are already rapidly changing the way we navigate our roadways. The emergence of these new technologies has the potential to drastically improve safety and save lives. But, as with any technology, it's important to ensure that it's implemented safely.

The ATC

Spearheaded by the Iowa DOT, the Iowa Advisory Council on Automated Transportation (ATC) was established to begin to consider the future of automated transportation in the state. The ATC seeks to create an automated vehicle-ready driving environment in Iowa for the safe movement of people and freight for a thriving economy. The ATC is comprised of leaders from various organizations across the state working to provide guidance, recommendations, and strategic oversight of automated transportation activities in Iowa.

The University of Iowa serves as a Co-Chair of the ATC for management and logistics, while also providing expertise in vehicle safety, policy, and education around advanced vehicle technologies. Additionally, our partners at Iowa State University provide knowledge of transportation infrastructure and operations.

Looking ahead

Over the past year, the ATC met quarterly to learn more about automated transportation and discuss recent legislation and issues in the state.

Four subcommittees support the ATC, incorporating even more leaders from across Iowa to ask more questions, provide additional insights, and assist us as we navigate our state's future with automated transportation. The subcommittees consist of Policy & Legislation, Economic Development, Infrastructure Readiness, and Public Safety & Enforcement. Issues discussed have ranged from statewide fiber networks to tech start-ups to freight following distances.

In the coming year, the ATC will continue meeting and working with stakeholders to determine a strategic roadmap for automated transportation in Iowa. The UI will continue coordinating and leading meetings, provide input, and help further develop the ATC website and communication materials.

> “The ATC unites leaders in a variety of roles and organizations from across Iowa. It’s about working together, collaborating and sharing insights, to help make Iowa an automated vehicle-ready state.”

Mark Lowe
Director
Iowa Department of Transportation

We're making a difference in transportation safety today and tomorrow

SAFER SIM
SAFETY RESEARCH USING SIMULATION
UNIVERSITY TRANSPORTATION CENTER

SAFER-SIM program

Safety Research Using Simulation (SAFER-SIM) is a grant-funded Tier 1 University Transportation Center that employs simulation techniques to address safety issues prioritized by the USDOT. Led by the University of Iowa, SAFER-SIM is comprised of a multidisciplinary team of researchers across five consortium sites. These team members specialize in human factors, engineering, computer science, psychology, public health, management sciences, and urban and regional planning and use innovative simulation approaches to promote safety. SAFER-SIM leverages research from a range of disciplines and state-of-the-art driving, bicycling, and pedestrian simulators to study how road users, roadway infrastructure, and new vehicle technologies interact and interface with each other.

43
research and outreach projects funded by SAFER-SIM

Providing education opportunities

Developing future leaders in safety research and simulation is a key function of SAFER-SIM's work. The center uses seminars, symposia, web-based discussions, and other opportunities to share its researchers' expertise. In 2019, the program developed the Simulation Boot Camp, a five-part webinar series presented by consortium experts. Every Tuesday during the month of April, webinars were presented on topics like experimental design, scenario design, development, and testing, conducting simulator studies, and data analysis. The Boot Camp was attended by nearly 200 participants from academia, industry, and government and recordings of the webinars can be found on the SAFER-SIM YouTube website.

Outreach

SAFER-SIM fully engages students at all levels of research and disseminates findings and techniques to the research community, safety professionals, and the public. Each year, we're involved in more than 50 outreach events with thousands of attendees. We're proud to participate in and even organize STEM events throughout our community and the state of Iowa.

For more information, visit
http://safersim.nads-sc.uiowa.edu

SAFER-SIM CONSORTIUM MEMBERS

The University of Iowa | UMass Amherst | UCF University of Central Florida | Wisconsin University of Wisconsin-Madison | Recinto Universitario de Mayagüez Universidad de Puerto Rico

During 2019, SAFER-SIM interacted with more than

6,000

individuals

Making technologies safer

Vulnerable road users

Roadway safety is about more than considering people behind the wheel of a vehicle. Vulnerable road users, like cyclists and pedestrians, are those most at risk in traffic. Although overall traffic fatalities have decreased in recent years, pedestrian and bicyclist fatalities are on the rise. In 2018, while overall US traffic fatalities decreased, pedestrian and bicyclist fatalities saw increases of 3.4% and 6.3%, respectively (Governors Highway Safety Association).

Nighttime roadways

Many vulnerable road user traffic fatalities occur at night. New vehicle headlamp technologies in use today are more adaptive and intelligent than ever before. Adaptive headlamp systems (AHS) already on the road can react to steering, speed, and elevation of a car and automatically adjust to illuminate the road ahead, whether it's straight in front of a driver or around a curve.

Various AHS being developed and tested could further reduce collisions between drivers and vulnerable road users by alerting both parties to the presence of the other. Possibilities include spotlights, brightening of the headlamps, or even projecting an icon on the road when approaching a vulnerable road user. This technology not only helps drivers but also warns bicyclists of a nearby vehicle, allowing these road users to potentially engage in safer rider behavior.

What we're doing

This year, we conducted an industry-sponsored project simulating a conceptual AHS capable of projecting shapes and designs on the road to research potential safety benefits in nighttime encounters between vehicles and vulnerable road users. We developed six driving experiments on the NADS-1 simulator with three conceptual AHS functions: a spotlight shining on the base of the vulnerable road user, a brightening of the headlamp, and an icon on the road. We observed the most meaningful effects with the use of the spotlight. The use of increased brightness and icon had more mixed effects.

AHS is not only beneficial for drivers, but also vulnerable road users, as it can alert them to vehicles and help them engage in safer rider behavior. In collaboration with our NADS-1 simulator work, the University of Iowa Hank Virtual Environments Laboratory conducted similar studies with their bicycling simulator. They examined the effectiveness of two different AHS designs to alert vulnerable road users to a vehicle's presence: one projected a box of white light beneath the vulnerable road user and the other projected a red icon in the roadway next to the individual, in addition to a white box beneath the rider. Results indicated that the box plus the red icon system produced the greatest safety benefit for riders in terms of both adjusting distance from the passing vehicle and, to a lesser extent, speed reduction.

We're continuing our commitment to working for all those who use our roadways, especially our vulnerable road users. Future studies funded by industry partners evaluating the possibilities with AHS are currently underway.

About **45%** of pedestrian fatalities occur between 9PM and 6AM. Another 25% take place between 6PM and 9PM.

- NHTSA Traffic Safety Facts (2016)

When arts and engineering collide

Unexpected collaborations

At the National Advanced Driving Simulator, we strive to be innovative in all that we do, and that extends to developing new collaborations and exploring unexpected opportunities. In 2018, NADS Director and associate professor of Industrial and Systems Engineering, Dr. Daniel McGehee, met University of Iowa Department of Dance assistant professor Dr. Christopher-Rasheem McMillan. During conversation, they learned that each had similar goals in their respective disciplines: they endeavored to avoid collisions on the road or on stage. This strikingly similar lexicon led them to develop a unique proposal: merging the arts and engineering through dance.

During their discussions, Dr. McGehee and Dr. McMillan knew that they wanted to create an innovative dance involving the intricacies and technology of automated vehicles. But what they didn't want was a dance that just had dancers acting like cars, bicycles, and pedestrians mimicking traffic and crashes. Dr. McMillan looked to practice-led research to investigate the "parameters and rules" that engineers use for designing automated cars and applied those concepts to dance making through the use of "choreographic thinking." The dance would not be demonstrative, in that it would not illustrate what automated vehicles do on the road. Instead, drawing upon design codes and information used to build these vehicles, the performance would attempt to illustrate how those ideas might be shown, shared, and evaluated.

Crash Dance: There Are No Accidents

From these plans, the performance *Crash Dance: There Are No Accidents* was born. Dr. McMillan worked with NADS and the UI College of Engineering's NEXUS arts program to fully involve engineering students and staff in every aspect of the dance, from construction of the set, special lighting, costuming, and music.

Dr. McMillan worked with engineering faculty and students to investigate the structures and codes used to make automated vehicles and how they avoid collisions. In developing *Crash Dance*, the show "programmed" the dancers to respond to certain sound and light stimuli with specific movement, like automated vehicles are programmed to respond to coded stimuli. Like vehicles, if the dancers were not given certain cues, they were not in movement.

To set-up these structures on the stage, some dancers were blindfolded and had to know the code. Some responded to light, some to sound. As an added complexity, the soundscape was created and changed each performance. Thus, the humans performing on the stage had to act in response to the flux in the music. If a sound didn't appear in the soundscape, the dancers didn't perform the programmed gesture. This required dancers to think in real time and resulted in a dance that was never the same twice.

In summary, this project pushed the boundaries of both fields while establishing interdisciplinary connections between the sciences and the arts, with student-centered learning at the heart of the collaboration.

Crash Dance premiered on the UI campus April 11-13, 2019.

SPONSORED BY

The National Advanced Driving Simulator | The University of Iowa | Office of the Vice President for Research | Obermann Center for Advanced Studies | Nexus Engineering and the Arts | The University of Iowa | Public Policy Center

Dance is usually about a thing... it's not *the* thing.

This dance *was* the thing. It used the actual code that engineers use for automated vehicles.

- Dr. Christopher-Rasheem McMillan, UI Department of Dance

Investing in the future of transportation safety

Our students

At the National Advanced Driving Simulator, we work with students in all phases of their college careers. From graphics design to program development to mechanics to working with research participants, our students receive a holistic, transformative educational experience that leads to a lifetime of success in a variety of fields.

Here, we've highlighted research projects from a few of our students. Each has a different background and all are pursuing degrees with the University of Iowa College of Engineering's Department of Industrial and Systems Engineering.

Zach Noonan
PhD candidate

A game theoretic decision-making approach to behavior planning of autonomous agents

Behavior planning is needed to navigate the complex interactions between human and machine agents as automated vehicle technologies become more abundant on our roadways. Through his research, NADS student Zach Noonan has sought to use an understanding of human decision-making combined with machine learning techniques to build a game theoretic model to both predict changes in mixed-traffic interactions and, ultimately, engineer adaptive behavior planning into vehicle technologies to make traffic interactions safer and more efficient. This year, Noonan presented his dissertation work on this topic at MIT and Oxford.

Nicole Corcoran
PhD student

A temporal analysis of safety driver disengagements in public roadway automated driving trials

Disengagement request and mileage data was recently released on Level 4 autonomous vehicles being tested on public roadways. From this data, NADS student Nicole Corcoran created a temporal metric which showed that there were typically 150-250 hours without a disengagement request. This new metric helps better understand disengagements relative to operational design domain. Expanding the content of this publicly-released data could then lead to a better understanding of the conditions under which safety drivers are functioning. Corcoran presented her research at the Human Factors and Ergonomics Society (HFES) meeting in Seattle this year.

Christopher Mitropoulos-Rundus
PhD student

Regenerative braking

Regenerative braking can be set to aggressive levels in some vehicles; simply lifting one's foot from the accelerator pedal is equivalent to braking. This past year, NADS student Christopher Mitropoulos-Rundus was involved in a SAFER-SIM study evaluating regenerative braking and safety. This work sought to answer questions about regenerative braking such as how much does it improve safety margins in forward collision events, how much regenerative braking is needed to realize a safety benefit, and does it increase the risk of rear-end collisions from a following vehicle?

Emily Shull
UI Psychology graduate and upcoming PhD student

Human-machine interfaces to convey feedback in automated vehicles

The next decade will see a rapid increase in the prevalence of partially-automated vehicles, where vehicle control is shared between the automation and human driver. In the near term, the driver will play a critical role in these vehicles as the safety fallback, responsible for controlling the vehicle during automation failures or in edge case situations. While drivers may be disengaged from driving while the automation is operating, it may be helpful for the system to convey feedback about approaching control transitions. NADS student Emily Shull helped lead a SAFER-SIM study to investigate the effectiveness of different human-machine interfaces for maintaining situation awareness during automated driving.


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