IOWA

NATIONAL ADVANCED DRIVING SIMULATOR

2020 ANNUAL REPORT

INSIDE

ADS for Rural America to launch summer 2021

CONTENTS

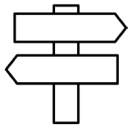
BY THE NUMBERS

10,089

PEOPLE IN OUR PARTICIPANT REGISTRY

1,362

ROAD SIGNS IN OUR VIRTUAL SPRINGFIELD GROUNDS



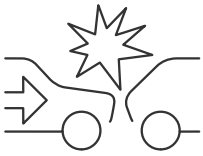
80+

MINISIMS™ IN USE WORLDWIDE

1994

THE YEAR THE UI RAN THE FIRST AUTOMATED DRIVING SIMULATIONS IN THE WORLD

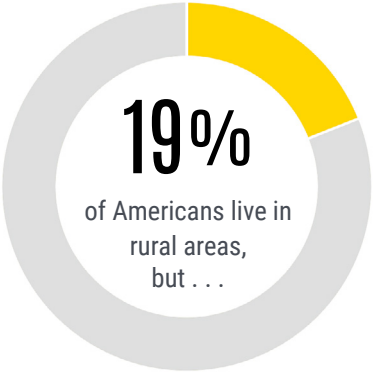
(on forward collision warning systems)

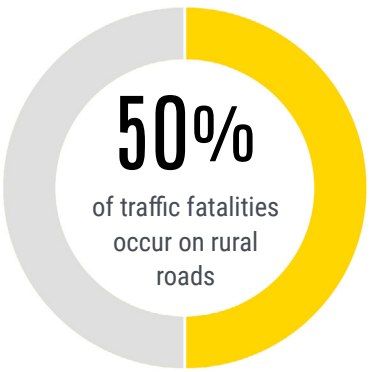


$7,026,769

U.S. DOT FUNDING FOR OUR ADS FOR RURAL AMERICA PROJECT

to study automated driving on rural roads. Here's why:





OUR PEOPLE

385

TOTAL YEARS OF DRIVING RESEARCH AND SUPPORT AT THE UNIVERSITY OF IOWA

24

FULL-TIME STAFF MEMBERS

20

UI FACULTY AND FACULTY PARTNERS

23

STUDENTS AND POST DOCS

10

NADS STAFF OR FACULTY WHO HAVE WORKED IN DRIVING RESEARCH AND SUPPORT AT THE UI FOR 20+ YEARS:

- Corey Kreutz: 31 years
- Mary Bender: 30 years
- Shawn Allen: 27 years
- Tim Brown: 27 years
- Dan McGehee: 27 years
- Omar Ahmad: 25 years
- Chris Schwarz: 24 years
- Cher Carney: 23 years
- Steve Cable: 21 years
- Jeff Gordon: 20 years

We are deeply grateful to all of our staff members who are dedicated to the pursuit of safer roadways.

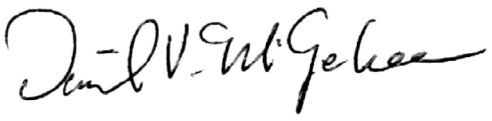
FROM OUR DIRECTOR

As we see 2020 moving into our rearview mirrors, this year has been one of challenges and opportunity. Doing driving research in the COVID-19 era has been a test for us and the University of Iowa more broadly. While many are diligently working from home, a handful are working in the facility while maintaining safe distances and following proper safety precautions. We worked hard to develop innovative protocols to keep our staff and research subjects safe inside our vehicles—whether in the simulator or on the road. Working with our global experts in infectious diseases at the University of Iowa Carver College of Medicine and internationally, we have taken the lead and developed in-vehicle protocols for our internal use as well as shared with the broader research community around the world.

In addition to dealing with COVID-19, we have made great strides this year in advancing the future of auto safety. The U.S. Department of Transportation award of the Automated Driving Systems (ADS) for Rural America contract was a validation that the NADS is among the most competitive and cutting-edge labs in the United States. This $7 million contract gets to a big gap in ADS research: rural America.

Unlike Silicon Valley and other 12-month sunshine states with dry roads, Iowa has more challenging roadways and environmental conditions—from narrow unpainted roads, to gravel and farm equipment. And not to mention winter! Together with our many partners, we will continue to lead at the national and international level.

These strides are not possible without our energetic, innovative, and nimble staff, students, and faculty. They provide the fit and finish that makes our research shine in global automotive safety. Peruse these pages, and our dedication and quality will speak for themselves.



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

‘MISSION FIRST, PEOPLE ALWAYS’

Harriet Nembhard became dean of the UI College of Engineering in June 2020

Harriet Nembhard’s research has taken a multidisciplinary approach to manufacturing and health care systems engineering. Her father was a captain in the U.S. Air Force, and she encapsulates her approach to leadership by borrowing the familiar military motto, “Mission first, people always.”

“‘Mission first’ means that we invest in the academic institution that we want to realize,” says Nembhard. “‘People always’ means that we prioritize the success and well-being of everyone in our community. I believe that putting these together propels us forward as a community of inclusive excellence.”

Q: How do you see the work that NADS does as contributing to the overall mission of the College of Engineering?

A: The work done at NADS fits squarely within our college mission in a number of key ways: it fosters a community that values respect and inclusion; it forges critical research and innovations that improve human health; and it engages industry, state, and federal agencies in partnerships that advance knowledge and promote economic development. I am eager to see how NADS can further embrace our public education mission, engage more young people in engineering, and help expand the community of researchers.

Q: NADS and its research program have now been around for more than 20 years. How does it fit more broadly into the mission of global health and safety?

A: NADS has indeed made the University of Iowa a global leader in vehicle safety research. As driving technologies continue to advance, research underway at NADS will make these technologies safer and more reliable for everyone. The next generation of automotive safety research will have a profound impact on human health around the globe.

I am also encouraged by the industry relationships that NADS has fostered over the years, relationships that highlight the real-world impact of our research and the economic value of engineering scholarship. Not only is NADS seen as an invaluable resource for industry partners, but it is also a critical source of data and information for government agencies and regulators who will determine what technologies can be promoted in the marketplace.

Q: You have expressed an intrinsic interest in technologies that are being developed at NADS. What is your personal interest in automated vehicles?

A: Without a doubt, automated vehicles are in our future. As a current driver of a Tesla, I may even find myself using these automated functions soon. The only way in which automated vehicles can become more mainstream, beyond lowering the price, is if consumers and government find them to be as safe as human drivers. In addition, not all vehicles have the same on-road performance and experience, which is why NADS’s current project on automated driving on rural roads is so important. These automated technologies need to be accessible to people who drive on highways in Chicago and Los Angeles as well as those using side roads in Mount Vernon and Pella.

*Read more Q&A with Dean Nembhard at **bit.ly/UI-Nembhard**.*

TOUR OUR TECH

Experience our 360° virtual tour at:

→ BIT.LY/NADS-360-TOUR

(available through June 2021)

THE NATIONAL ADVANCED DRIVING SIMULATOR

OUR MISSION

Make our roads safer by researching the connection between humans and vehicles

OUR RESEARCH

We conduct research with simulators and on-road vehicles. Funded by government and industry partners, our expertise includes:

- Human factors
- Distracted driving
- Drowsy driving
- Drugged driving
- Connected and automated vehicles
- Mobility
- At-risk populations (older and novice drivers)
- Simulation science
- Crash biomechanics
- Safety and crash data analysis

OUR SIMULATORS

NADS-1 simulator: One of the world's most realistic driving simulators

NADS-2 simulator: A fixed-base simulator with high-resolution graphics

NADS miniSim™: A low-cost PC-based portable simulator available for purchase (see page 26)

OUR ON-ROAD VEHICLES

- Tesla Model S75D
- Lincoln MKZ
- Volvo XC90
- Toyota Camry XLE
- Ford Transit shuttle bus

Driving Research
at the University of Iowa

A Brief History

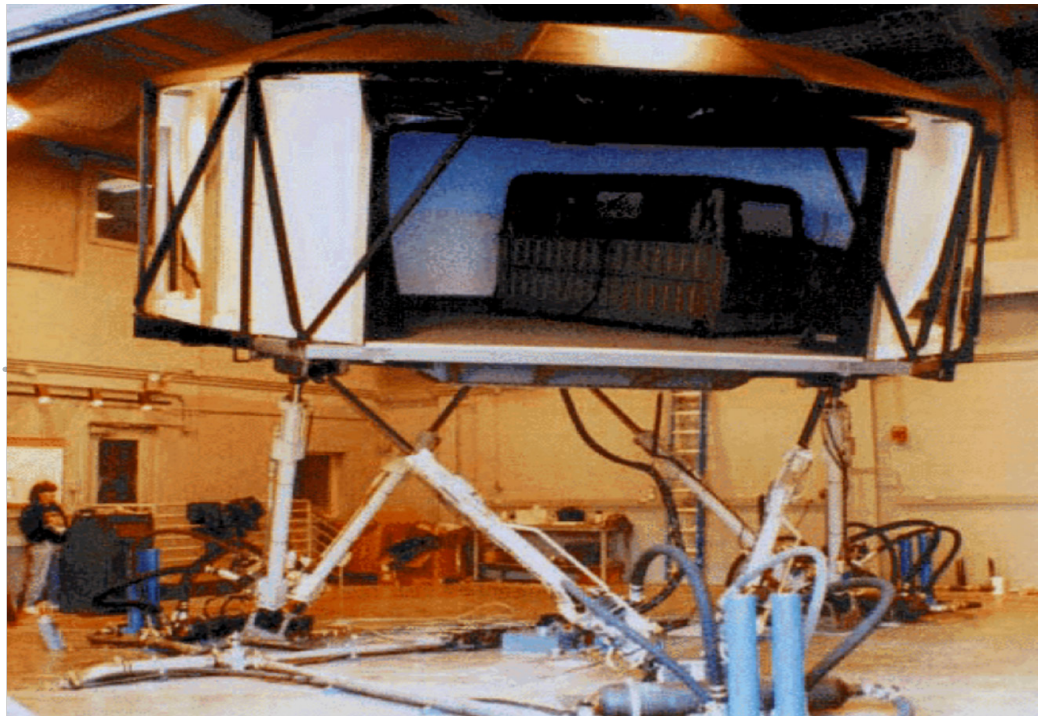
1981
Edward J. Haug, a professor of mechanical engineering, founds Center for Computer-Aided Design (CCAD) to conduct research in dynamics.

1989
The initial **Iowa Driving Simulator** configuration is operational, the first in the nation. The motion base was later added in 1993 and came from a B-52 bomber simulator.

1992
NHTSA selects the UI to house the new National Advanced Driving Simulator (NADS), which would become the most sophisticated research driving simulator in the world.

1994
The first automated driving simulations **in the world** are done at the UI. Forward collision warning and ACC systems are designed, developed, and tested for NHTSA.

1997
NADS begins building virtual replicas of military proving grounds, such as the Aberdeen Proving Ground in Maryland (pictured next page), where the government tests military vehicles.



Aberdeen Proving Ground virtual replica

Directors Past and Present

Ed Haug: 1997–1998
L.D. Chen: 1998–2006
Karim Abdel-Malek: 2006–2008
Herm Reininga: 2008–2016
Daniel McGehee: 2016–present

1998
Ground is broken for the new NADS facility.

Pictured: Ed Haug, UI president Mary Sue Coleman, Iowa Senator Tom Harkin.

1999
UI begins first **drugged driving** study: "Effects of Fexofenadine, Diphenhydramine, and Alcohol on Driving Performance."

2001 (fall)
NADS-1 is operational. The facility is operated on a self-sustaining basis by the UI. NHTSA owns the simulator while the UI takes responsibility for operation and maintaince. UI owns the building, land, and the software that runs the NADS-1.

2001
The first formal study done on the NADS-1 is a study on tire failure and loss of control.

2002
A wireless phone study is conducted—the first at NADS about driver distraction.

2003
NADS begins work with John Deere, and a tractor cab is created for use in the NADS-1 simulator.

2005
NADS builds a portable simulator for outreach to high school students, which eventually leads to the creation of the **miniSim** program in 2009.

2006
- The **NADS-2 simulator**—the second simulator at NADS—is ready for business.
- Based partially on research done at NADS, **NHTSA mandates** that all new vehicles must have electronic stability control.

2011
- The first cannabis study on driving performance is conducted at NADS.
- The first on-road vehicle is purchased for NADS research, a Toyota Camry.

2013
NADS is awarded a grant that would grow to $11.2 million over eight years from the U.S. DOT to fund **SAFER-SIM**: Safety Research Using Simulation.

2015
MyCarDoesWhat.org campaign launched to educate consumers about advanced driver assistance systems.

2016–2018
Automated vehicles are added to the NADS fleet: a Volvo XC90, Tesla Model S75D, and Lincoln MKZ.

2019
U.S. DOT awards NADS a **$7 million** grant for the Automated Driving Systems for Rural America project.

ADS FOR RURAL AMERICA

TESTING AUTOMATED VEHICLES ON RURAL ROADS

Automated Driving Systems (ADS) for Rural America is a demonstration project using a custom, automated Ford Transit shuttle bus on rural roads—thanks to a $7 million U.S. DOT grant awarded to the UI in spring 2020.

→ ADSFORRURALAMERICA.UIOWA.EDU

Project goals

1

Improve safety on our nation's roadways with the integration of automated driving systems, as an estimated 94 percent of serious crashes are due to human error.

2

Represent rural roadways in AV research, exposing the vehicle to sharp curves and grades, gravel and unmarked roads, animals or slow-moving equipment on the road, and a variety of Iowa weather conditions.

3

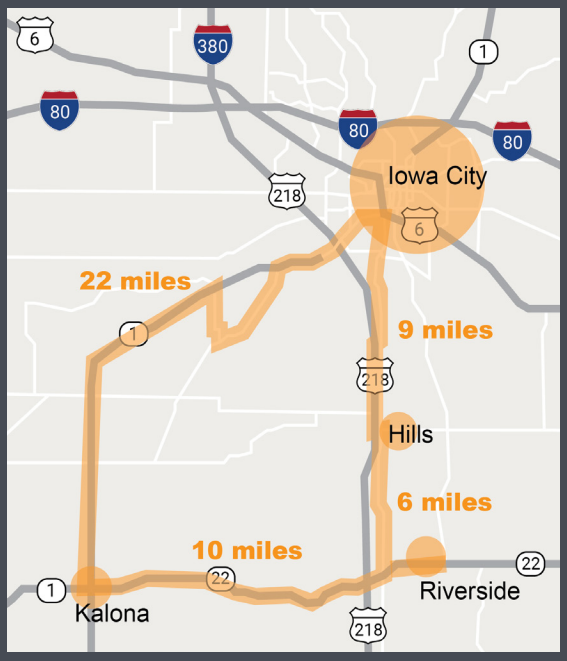
Broaden mobility and improve quality of life: Show how automated vehicles can provide transportation options for those not able to drive, such as aging populations and those with disabilities.

"Mobility means independence for a lot of these folks who cannot drive themselves, such as the elderly or those with certain disabilities. So in a few decades when fully automated vehicles become more common, this population could have a lot to gain from this technology."

— Omar Ahmad, project manager

The route

The shuttle bus will follow a 47-mile route through Iowa City, Hills, Riverside, and Kalona and navigate parking in each city. A safety driver will be behind the wheel at all times.



Midwest built, Midwest partners

Our vehicle has been all over the Midwest in its production journey. An American-made vehicle, the Ford Transit chassis was assembled at the Ford plant in Claycomo, Missouri (a suburb of Kansas City).

Next it was sent to Starcraft Bus in Goshen, Indiana, where the body was installed and it was made ADA compliant (e.g., wheelchair lift added).

Then it made its way to our partners **AutonomouStuff** in Morton, Illinois. AutonomouStuff is instrumenting it with automated technologies. In the meantime, our partners **Mandli Communications** in Madison, Wisconsin, will create high-definition maps of our route. We've also been partnering closely with the **Iowa DOT**.

Data

Data will be publicly available on our website after each of the eight increasingly complex phases of the project, the first to begin in summer 2021. Data collected will help identify challenges, opportunities, and insights relevant for U.S. DOT safety and rule-making priorities.

Types of data to be collected:

- Video data from the safety driver to examine kinematics/performance/workload
- Questionnaire data from the riders regarding trust and acceptance
- Physiological data from riders and safety driver regarding stress/anxiety
- Automation performance data, documenting challenges
- Data on road surface state, grip, and surface temperature
- Video data of participants will also be available, but will have restricted access to protect their privacy

Participants

Individuals from local communities will be recruited in mid-2021 to be passengers in the vehicle. We will be looking at people's comfort with the technology. Participants will:

- Be age 65 or older or
- Have a disability that affects their mobility or have low vision impairment (age 25 or older)

More information

Email **nads-contacts@uiowa.edu** with questions or ask to be added to our ADS newsletter mailing list for project updates.

Those interested in participating may sign up for our driving studies registry at **drivingstudies.com**.

Follow us:

@NationalAdvancedDrivingSimulator

@DrivingSim

Visit:

→ ADSFORRURALAMERICA.UIOWA.EDU

NADS FEATURED IN *IOWA MAGAZINE*

Iowa Magazine—the magazine for University of Iowa alumni and friends—featured NADS's research on automated driving in their winter 2020–21 edition.

The following is an excerpt, written by Josh O'Leary. Read the full text and watch new video coverage at:

→ FORIOWA.INFO/NADS

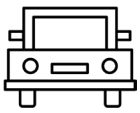
The past and present of transportation intersect not far from Iowa City. Near the small town of Kalona, just a 30-minute drive south of the University of Iowa, horse-drawn buggies clop through the Amish countryside on their way to the bakery or general store. Meanwhile, modern-day sedans and SUVs zip past. They're guided by pinpoint GPS mapping, lane-keeping cameras, and collision-detection systems that light up the dash when they approach a slow-moving buggy or tractor.

Soon a vehicle from the future will also share the road here. UI engineers plan to roll out a new automated vehicle packed with research instruments for a multi-year study beginning in 2021. It's not quite a DeLorean, but the customized, automated Ford shuttle bus will travel in a 47-mile loop, carrying research subjects through Iowa City, Kalona, Riverside, and Hills. Fueled by a $7 million research grant from the U.S. Department of Transportation, the vehicle will gather data on the challenges rural roads present to automated driving systems and study how emerging technology can help older residents in rural communities overcome mobility barriers.

The project is the latest mile marker in a long history of roadway safety research by the UI-based National Advanced Driving Simulator. NADS has been an international pacesetter in studying how humans interact with their vehicles since 1992, when the National Science Foundation and the National Highway Traffic Safety Administration selected Iowa to host the center over five other universities. Many of the crash avoidance features that are now standard in automobiles were first tested at Iowa, and today, NADS serves as one of the world's top hubs for advanced automotive driving research.

. . . continued at ***foriowa.info/nads***

ADAPTING TO COVID-19



NADS provides national leadership on COVID-19 driving research protocols

Since the early days of simulation and in naturalistic driving, NADS has often taken the lead to establish the gold standard in human subjects research in our unique environments. This year was no different.

With the help of many NADS staff members, Director Daniel McGehee made recommendations for human subjects testing in driving research for the COVID-19 era to the national Transportation Research Board's (TRB) Committee on Vehicle User Education, Training, and Licensing mid-year meeting this past September.

How to keep people safe in driving research—in both simulators and on-road vehicles—is not something that had been widely shared or standardized in the driving research community, so McGehee sought to change that.

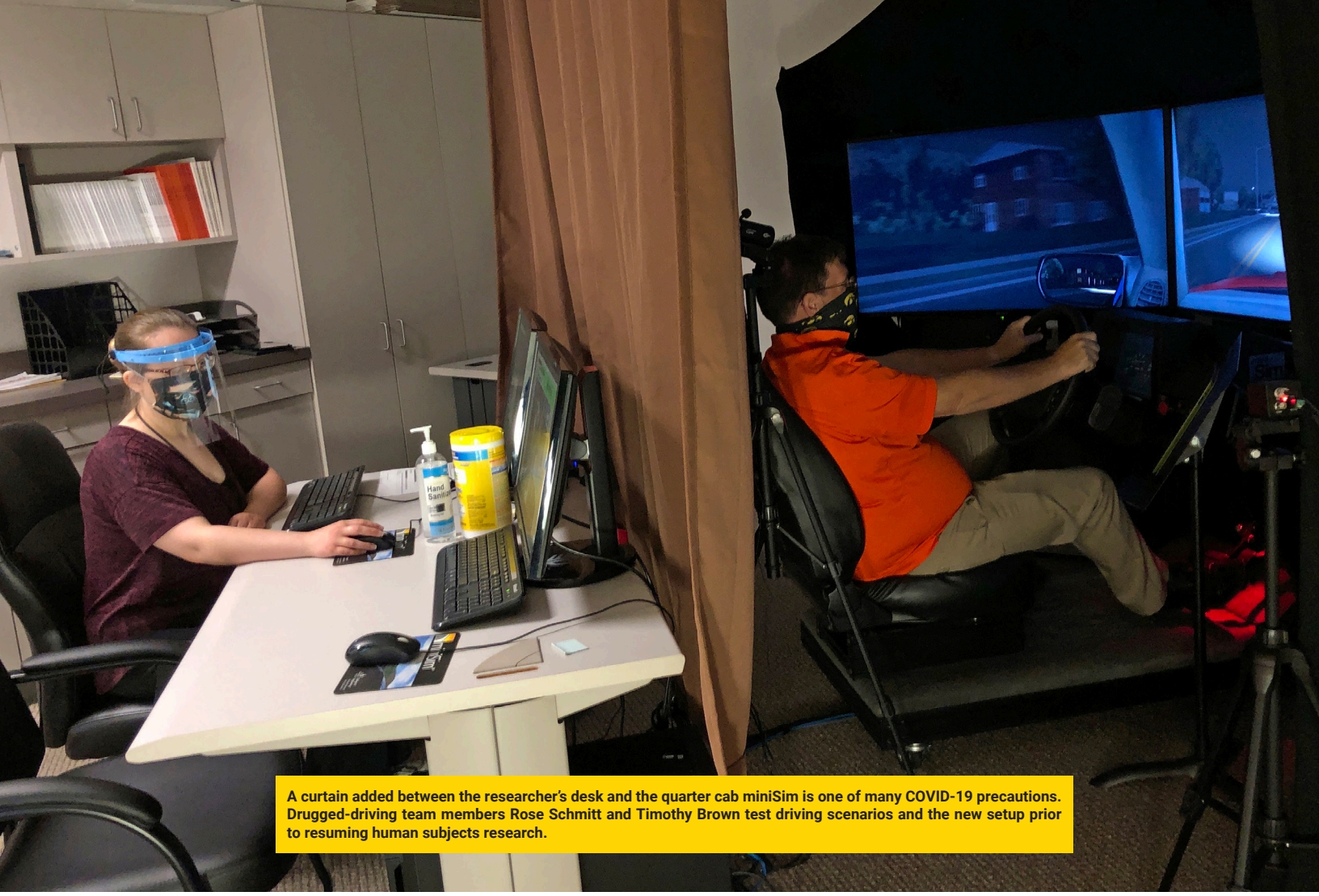
McGehee consulted with various infectious disease experts, including Loreen Herwaldt, MD, a University of Iowa infectious disease and COVID-19 expert and epidemiologist. Members from the World Health Organization and the past president of the Canadian Infectious Disease Society also contributed to the recommendations.

The recommendations (shown below) were met with an overwhelming positive response from the TRB.

RECOMMENDATIONS

To safely conduct driving research in simulators and on-road vehicles during COVID-19:

- Subjects and experimenters wear three-layer surgical masks. Experimenters also wear a face shield when in the same room as a subject.
- If experiments require an unmasked face (e.g., to read facial expressions), exclude on-board personnel if possible.
- Minimize talking in a shared vehicle to reduce the expression of droplets.
- Keep cooling fans on low speed.
- Open windows/sunroof for fresh air.
- Install HEPA filters in HVAC systems.
- Use CDC appropriate cleaning protocols on all surfaces including windows in the vehicle or simulator cab before and after each subject.
- Pre-screen subjects before and at arrival for the standard COVID-19 symptoms, and at arrival conduct temperature checks to ensure that they are not above 100° F.



A curtain added between the researcher's desk and the quarter cab miniSim is one of many COVID-19 precautions. Drugged-driving team members Rose Schmitt and Timothy Brown test driving scenarios and the new setup prior to resuming human subjects research.

New protocols for the NADS facility

Rewind to March 2020 when the COVID-19 outbreak began: University of Iowa research was suspended, and all staff were to work from home. Throughout the summer, a committee of NADS staff members developed 45 pages of guidelines to safely bring NADS staff back to work and resume research in a phased approach. First, a small handful of staff members began working in the building (only those who needed to be on-site), and eventually human subjects research resumed in late August. The vast majority of NADS staff members continue to work from home at the release of this Annual Report (December 2020).

The new guidelines included disinfecting instructions, safety protocols for every area of the building and vehicles (including max occupancies), social distancing and other signage, building traffic flow, meeting protocols, and building filtration updates, among other protocols.

The team also established a new process and committee—called the Resource Access Coordination Committee (RACC)—that manages staff access to shared building resources (such as the use of the simulators or other shared work areas), and maintains a schedule to minimize the number of staff members in the building at any time.

The NADS team has been incredibly adaptable in the face of these new challenges as we all learn how to safely live in a COVID-19 world.

Note on photos: Any group photos in this Annual Report that show people not wearing masks were taken prior to the COVID-19 pandemic.

CANNABIS AND DRIVING

Taking alcohol, cannabis, opioids, or other drugs can significantly impact the ability to safely control a vehicle, as well as the ability to notice and respond to hazards on the road. Our research aims to understand

- How drugs affect driving performance
- The relationship of drug pharmacokinetics (how drugs are processed in the body) to the changes in driving performance, and
- How impairment from drugs that impair driving performance can be detected.

Driving habits of regular users

NADS researchers recently found that regular cannabis users drive differently than non-cannabis users—even while not under the influence of cannabis.

Young adult drivers who use cannabis—but were sober at the time of our study—drove slower but also steered significantly less often and used the gas pedal less often than drivers who did not use cannabis. This suggests that effects of cannabis use persist and may lead to detrimental driving behaviors even after intoxication has subsided. These findings have implications for legislation in support of legalizing cannabis, because sober cannabis-using drivers may still be a public health concern.

When is it safe to drive after cannabis use?

In drivers who are impaired by alcohol usage, there's a clear way to determine when it's not safe to drive. But how can you tell when it's not safe to drive due to cannabis use?

That's the goal of an ongoing NADS study. The team is partnering with Advanced Brain Monitoring, who will be using the data for the development of an app called Cannabis Impairment Detection Application, which aims to detect levels of impairment due to cannabis use.

"We want to know when someone is impaired so we can differentiate somebody who used cannabis two days ago, but it might show up on their system, versus somebody who used it an hour ago and is not safe to drive," says Tim Brown, study PI and director of drugged driving research.

The research team is observing brain activity during subjects' reactions to stimuli; they are testing physiologic responses including blood pressure, heart rate, and where the eyes are focused; and they are measuring reaction times while braking or accelerating. Subjects will receive one each of three possible doses of THC across three study visits, one of which is a placebo dose.

See some of our other major drugged driving research findings from the past 10 years at **nads-sc.uiowa.edu/drugged_driving.php**.

Cannabis dose prior to vaporization

DRUGGED DRIVING RESEARCH PROCESS

Curious how we run our clinical research studies? Here are the basics.

Pre-award

- If we are developing the protocol, identify what is already known about how the drug affects performance, develop a study hypothesis, and define driving simulation requirements. Draft study protocol.
- If there is already a protocol, work with sponsor on details and timeline.

Study preparation and planning

- Drug supply is obtained. In the case of cannabis, it is federally supplied.

Recruitment, enrollment, and informed consent process

Screening human subjects

- Review inclusion and exclusion criteria, and verify eligibility.
- Conduct physical and psychological exams as appropriate.
- Screen for propensity for simulator sickness.

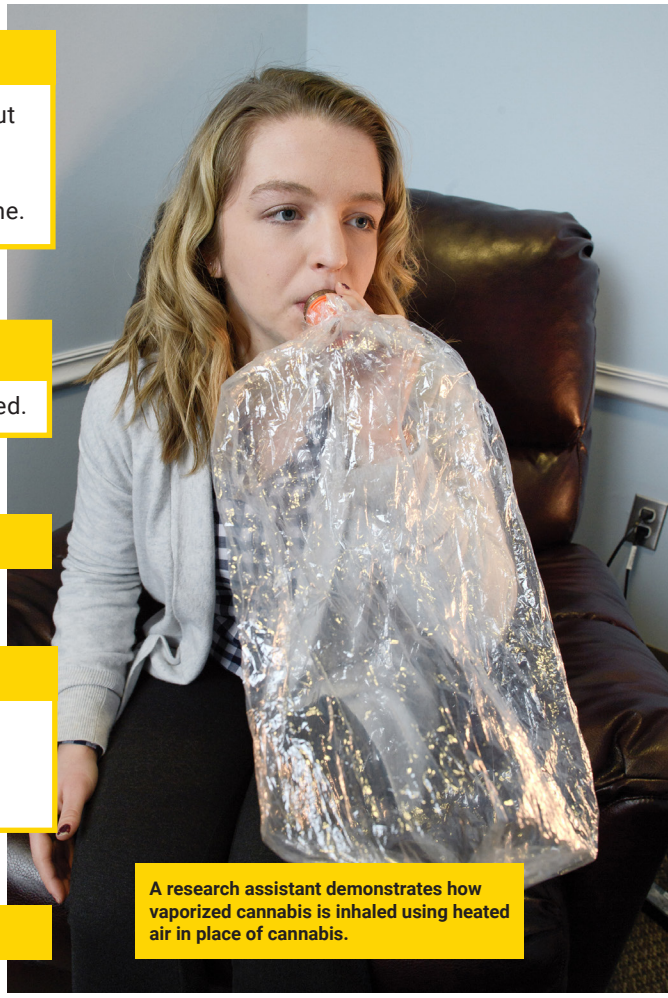
Randomization: subject assigned to experimental condition

Data collection

- Follow detailed study procedures to dose subject:
  - For cannabis this is **vaporization**.
  - This could also be an encapsulated or intravenous administered drug.
- Collect study-related data (driving data, biological samples pre- and post-dose for pharmacokinetic analysis, etc.).

Data processing and analysis

Reporting and results, summarize findings, study closure



A research assistant demonstrates how vaporized cannabis is inhaled using heated air in place of cannabis.

Cannabis vaporization procedure

- A dose of 500 mg of plant material is measured from the frozen supply.
- It is humidified in a secure storage area the night before use.
- The plant material is ground and then placed in the filling chamber.
- An inhalation balloon is attached to the chamber and then connected to the preheated vaporizer.
- The plant material is vaporized into the balloon.
- The balloon is then provided to the subject, who inhales the vaporized cannabis over a period of 10 minutes.

TEENS AT THE WHEEL

When parents are in the vehicle with their teenage driver, crash rates are low. However, as soon as teens are by themselves, the crash rates skyrocket. Can new-driver training programs be used to effectively lower those rates?

Elizabeth O'Neal, a postdoctoral researcher with NADS and the Department of Psychological and Brain Sciences, and Michelle Reyes, senior research associate, put teens into a simulator to find out. They posed the following research questions:

- Does a teen's ability to anticipate hazards on the roadway change after engaging with one of two novice driver training programs designed to improve hazard anticipation skills?
- Does training improve hazard anticipation skills over and above independent on-road driving experience?

In a project funded by the AAA Foundation for Traffic Safety and SAFER-SIM, they evaluated two novice teen driver training programs. Participants in the study:

- Completed a baseline drive, then completed one of the two trainings (or neither if in the control group)
- Returned after 6 weeks to do a post-training simulator drive
- Returned after 4.5 months for a third, follow-up simulator drive

The team is now in the process of analyzing data from the third drive. They are combining eye tracking and simulator data to code each driver's level of situational awareness to better understand how well the novice drivers are perceiving and responding to potential roadway hazards. They plan to wrap up data analysis and reporting in FY21.

So what's next for O'Neal? "I'd like to find out: What can we do to more effectively train parents to be better instructors of their teen drivers?" she says.

She hopes to modify one of the training programs and test its ability to train parents to be better driving instructors by comparing participants that do and do not complete the training.

Elizabeth O'Neal, postdoctoral researcher

Young driver study: Crash rates

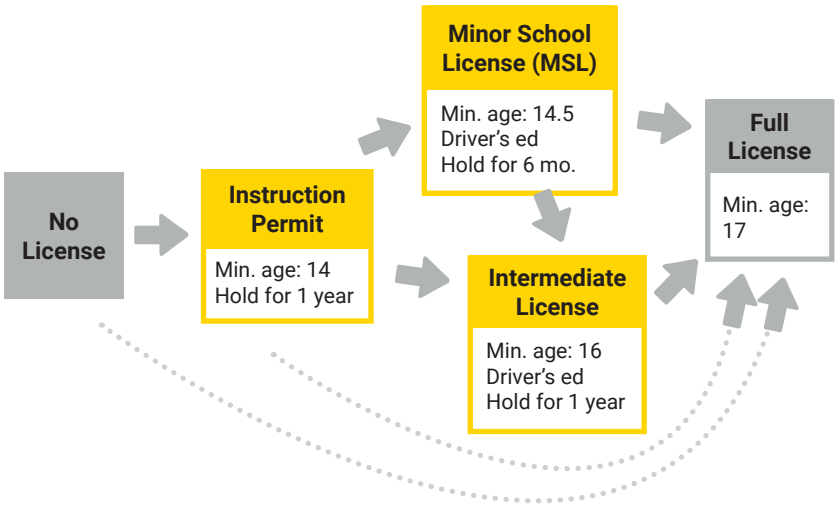
A project led by Michelle Reyes used state driver's licensing data in combination with crash data to study young driver crashes. Crash rates based on the number of licensed drivers were calculated on a monthly basis to help evaluate graduated driver licensing policies in Iowa.

The major findings included:

- Holding an instruction permit for a longer time prior to getting an intermediate license was associated with lower crash rates.
- Minor school license (MSL) drivers had lower crash rates than intermediate drivers, but MSL drivers were also over-represented in fatal and severe injury crashes.
- Older young drivers (i.e., 17- to 20-year-olds) holding instruction permits were over-represented in crashes and were also more likely to be driving without a supervisor in the vehicle.
- Fatal crashes were much more likely to occur at night on summer weekends.

What's next? Building off previous research, Reyes is working to calculate teen crash rates and crash characteristics by license type (instruction permit, minor school license, or intermediate license), age, and duration of licensure.

Paths to full licensure in Iowa



"I've been fortunate to collaborate with many great people at the Iowa DOT and the Statewide Traffic Records Coordinating Committee who care about using data to improve safety on Iowa's roads."

—Michelle Reyes,
senior research associate

Ongoing NADS/Iowa DOT projects are asking:

What are the outcomes of motor vehicle injuries for adults in the back seat, and how do seatbelts affect the severity or types of injuries sustained?

What are the impacts of road conversions from 4- to 3-lane street configurations on businesses and emergency response in Iowa communities?

What do the coded numbers from crash reports really mean? Reyes is part of a team creating a crash data dictionary that will give users a better understanding of what really happened during a crash.

ARE DRIVERS READY FOR AUTOMATED VEHICLES?

NADS is committed to making vehicle technology safer and easier to use. Our team is focused on understanding the challenges associated with varying levels of vehicle automation, from adaptive cruise control to full self-driving. To do this, we combine our expertise in human factors engineering and psychology with multimodal research tools, using a combination of high-fidelity driving simulators and on-road research vehicles to study the relationship between humans and vehicle technology. Here are a few highlights from the past year.

Mental Models of Vehicle Technology

Research question: How does a driver's understanding of adaptive cruise control affect driving performance?

Sponsors and partners: AAA Foundation for Traffic Safety, SAFER-SIM, and University of Massachusetts–Amherst

Method: A questionnaire was developed to evaluate user understanding of adaptive cruise control (ACC), and users were grouped based on their understanding. Next, researchers compared driving performance in the NADS-1 simulator. The team recreated a Toyota ACC display in the simulator.

Findings: Subjects with strong understanding of ACC responded earlier when the system failed to detect an object ahead. "We think this is due to uncertainty about how the system will behave," explains John Gaspar, director of human factors research. "People who have poor understanding of the system come closer to collisions, because they tend to wait to see if the vehicle will respond."

Next steps: A second year of the project is tracking new owners of vehicles equipped with ACC to explore how user understanding changes over time during the initial interactions with a technology.

Rose Schmitt, research logistics, and John Gaspar, director of human factors research, in the NADS-1 simulator control room

User Experience

Research question: Do people prefer a more conservative or more aggressive automated vehicle? How does that system behavior impact drivers' trust and perception of the technology?

Sponsor: Hyundai

Method: The project used the unique motion capabilities of the NADS-1 to create two models of automated driving behavior: an aggressive system and a conservative system. Subjective ratings and eye tracking data were both collected.

Findings: Users were more comfortable with automated driving systems that had conservative behavior (such as slower acceleration) rather than aggressive behavior. Comfort and trust also increased over time in both models.

Collaboration: A researcher from Hyundai Korea, Jayoon Goo, contacted NADS to do the study. He visited Iowa for nine months to work with NADS researchers on the project.

The NADS's Tesla Model S75D at the Iowa City Airport decommissioned runway

Controlled Driving Studies

Research question: How quickly do drivers transition back to control following periods of non-driving in automated driving?

Sponsor: Toyota Collaborative Safety Research Center

Method: On a decommissioned airport runway, a total of 155 subjects engaged in different non-driving tasks (such as texting or using the car's interface) while driving the Tesla Model S75D in Autopilot mode. The Autopilot is set to turn off at a certain point, and researchers compare how quickly the driver transitions back to the control of driving.

Collaboration and outcome: The video data from this study will be used by the University of California–San Diego to develop a computer vision algorithm that will classify how ready the driver is to take over based on where their eyes, hands, and feet are located.

Next steps: As part of a driver modeling study, NADS researchers have recreated events in the simulator. Next they will compare takeover time on the runway driving versus the simulator environment.

Transition of Control (TOC)

Research questions: How does interface design impact transition of control in automated vehicles? How does the timing and sequence of messaging influence the transition from automation to manual driving?

Sponsor: National Highway Traffic Safety Administration (NHTSA)

Method: This project in the NADS-1 simulator is one of the first to look at driver behavior in a system that mimics a traffic jam. The system—called Traffic Jam Auto Drive—controls the vehicle during low-speed congested driving conditions. It was developed in-house and uses NADS's automation model. NADS is studying both normal transitions and when the automation fails to live up to expectations.

Using the unique motion capabilities of the simulator, researchers don't just identify if the driver is able to take over control, but also rate the quality of that takeover. "We're finding that threshold between what's safe and unsafe—so we need a high-fidelity simulator to do that," explains Gaspar.

Next steps: As part of a series of TOC studies funded by NHTSA, NADS also won a $1.45M award—announced in fall 2020. This one will ask: How long does it take to build sufficient situational awareness to safely resume manual driving? What are the risks if the transition time is too short? What's the most effective interface and alert design for a safe transition?

Thanks to our staff

Thank you to our research staff members below who collaborated on these projects, in addition to a number of development staff, other employees, and students who supported this work:

- John Gaspar, PhD
- Cher Carney, MS
- Emily Shull, graduate student
- Cheryl Roe, BS
- Rose Schmitt, BS
- Chris Schwarz, PhD
- Stephen Baek, PhD
- Michelle Reyes, MSE
- Omar Ahmad, MS, MBA
- Timothy Brown, PhD
- Sidney Scott-Sharoni

CONNECTED SIMULATION CAPTURES REALISTIC HUMAN INTERACTION

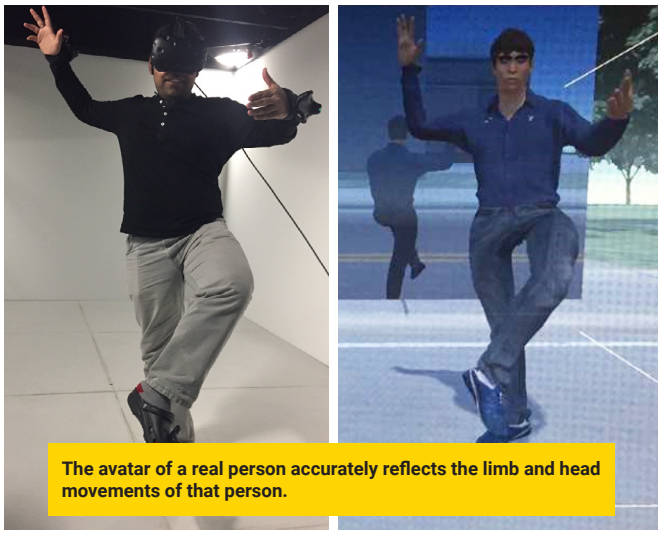
NADS recently wrapped up a multi-year project on connected (a.k.a., distributed) simulation funded by the Federal Highway Administration. While most simulations in driving research involve one human participant, this project involved multiple people interacting in the same virtual environment.

A driver in the NADS-1 simulator could see and interact with an actual pedestrian who was wearing a virtual reality headset and walking around in another part of the facility. The pedestrian and the driver could see each other's head and limb movement through their digital avatars, and they could gesture at each other to visually communicate.

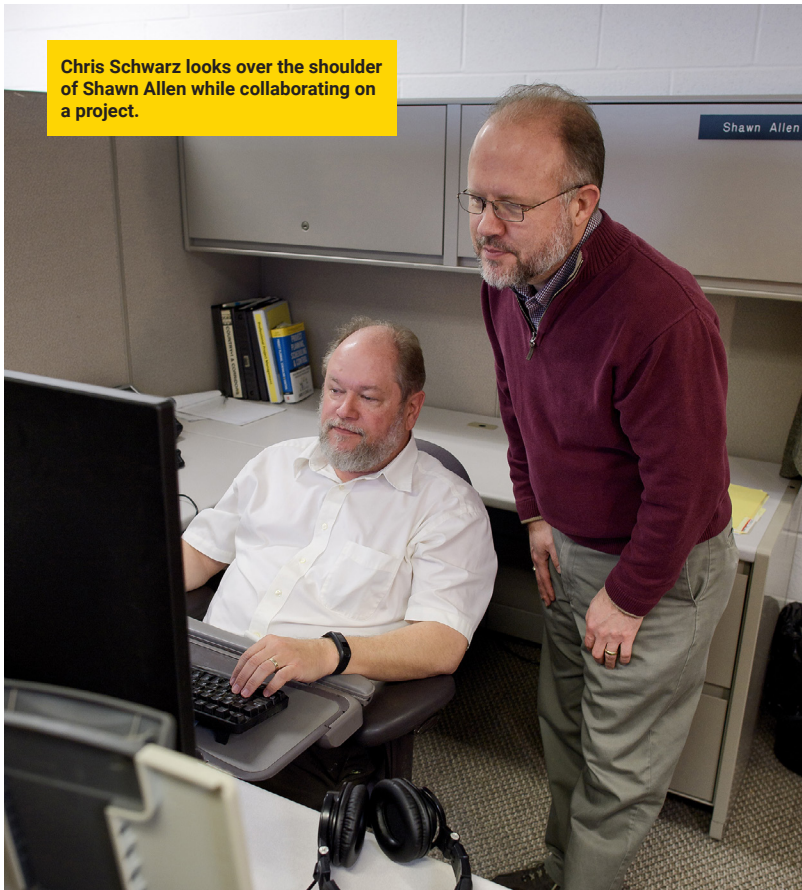
The goal? The team wanted to know if participants in the simulator would behave differently if they were interacting with the avatar of a real person instead of a computer-generated (agent) pedestrian.

The team completed three major aims for the project:

1. Develop the technology for connecting real-time driving and pedestrian simulators.
2. Create realistic avatars to represent the tracked motions of real drivers and pedestrians.
3. Design and conduct an experiment in which pairs of naive drivers and pedestrians interacted in a shared virtual world.



The avatar of a real person accurately reflects the limb and head movements of that person.



Chris Schwarz looks over the shoulder of Shawn Allen while collaborating on a project.

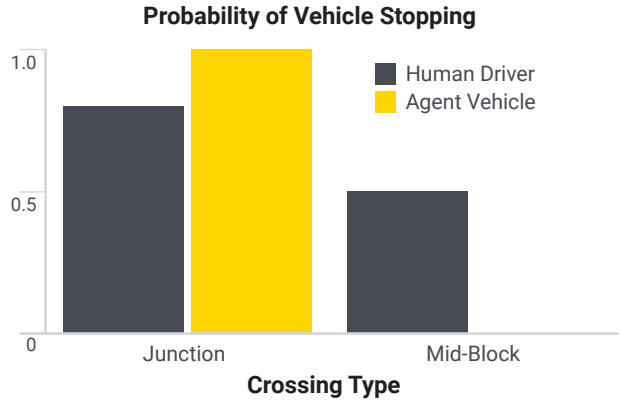
Findings

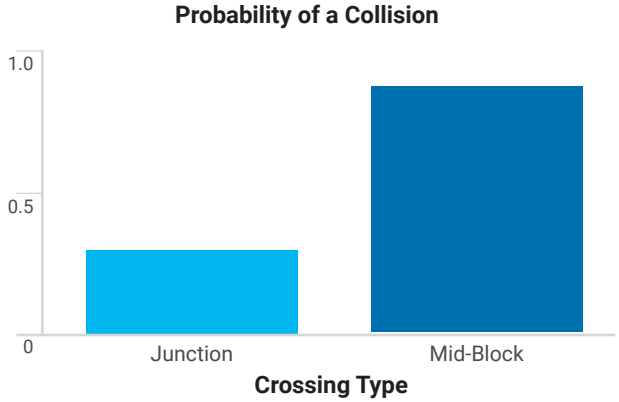
The research team concluded that there is benefit to using these types of interaction while studying safety.

“It gave us a deeper understanding of how people interact,” said Chris Schwarz, director of engineering and modeling research.

Not only were human drivers more likely to slow down and stop than the agent vehicles, but human pedestrians were also more likely to cross in front of human drivers than agent vehicles. So it did appear to affect the behavior of both parties, even when over half of the participants couldn’t distinguish which simulations were avatars of real people and which were computer-generated agents.

Two crossing types were compared: at junctions and at mid-block. The agent vehicles were not programmed to stop at the mid-block crossings, whereas drivers were more likely to come to a stop or slow down at the mid-block crossings. When human pedestrians crossed at mid-block, the driver always stopped to avoid hitting them, but the agent vehicles often had a collision.





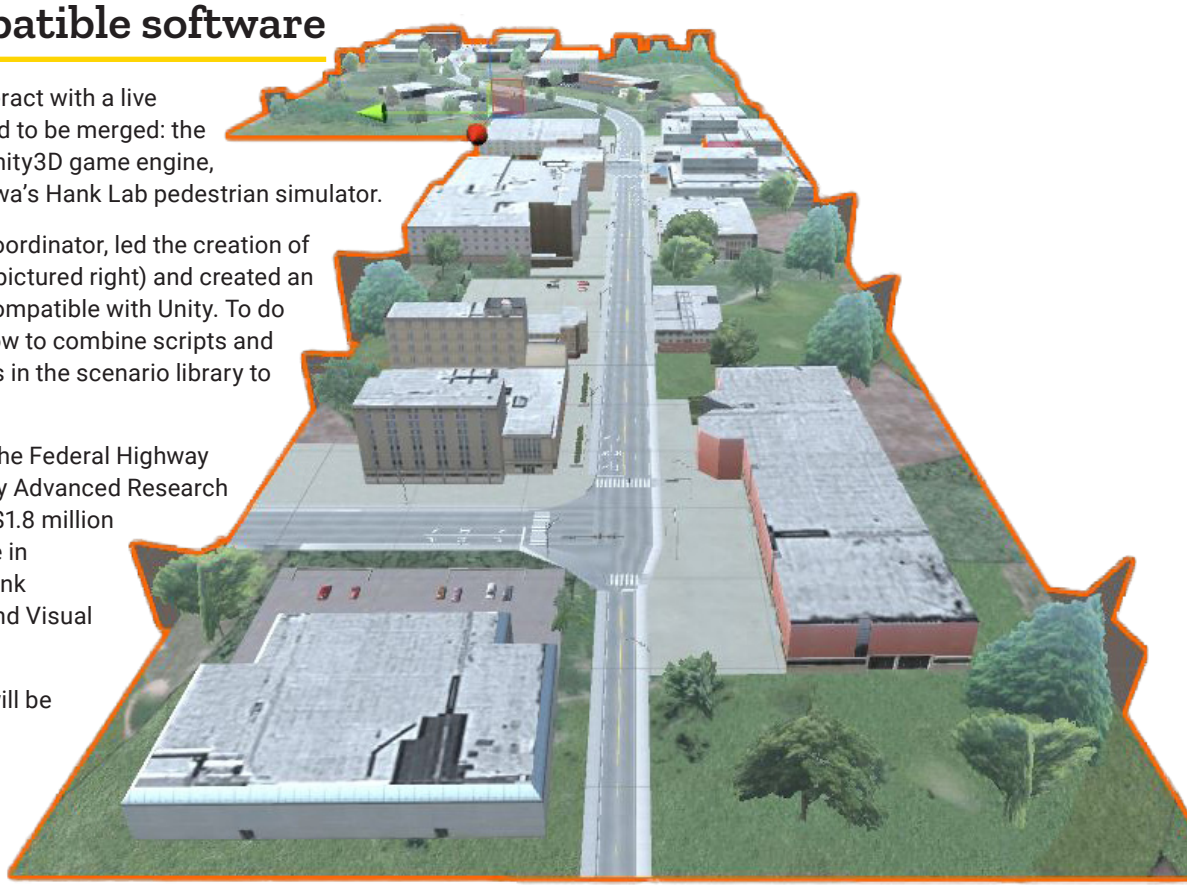
Creating compatible software

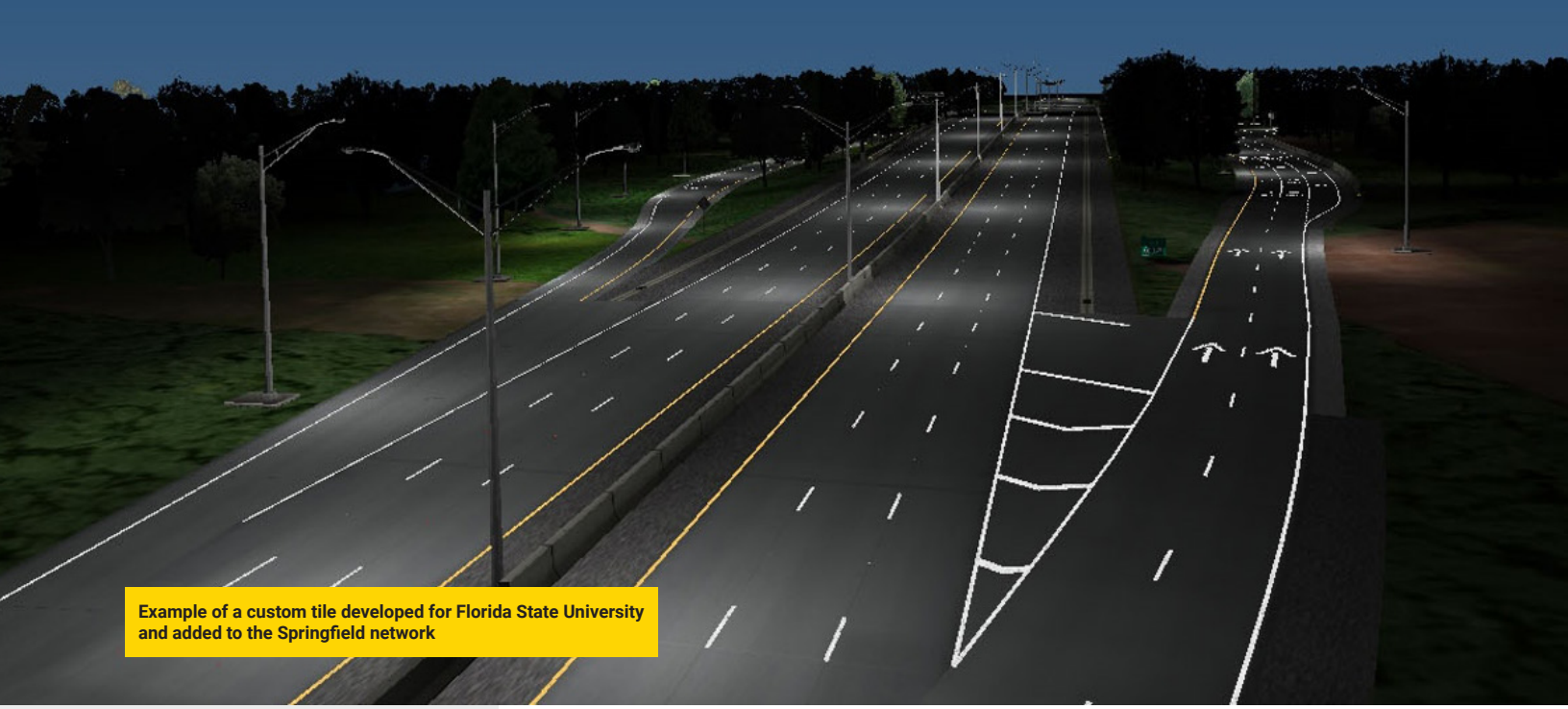
In order for the driver to interact with a live pedestrian, two systems had to be merged: the NADS-1 software and the Unity3D game engine, used by the University of Iowa’s Hank Lab pedestrian simulator.

Shawn Allen, engineering coordinator, led the creation of a new virtual environment (pictured right) and created an object database that was compatible with Unity. To do this, he developed a workflow to combine scripts and manually processed objects in the scenario library to Unity.

This work was done under the Federal Highway Administration’s Exploratory Advanced Research (EAR) program based on a $1.8 million grant. The project was done in collaboration with the UI Hank Virtual Environments Lab and Visual Intelligence Lab.

Interaction with bicyclists will be added in future work.





Example of a custom tile developed for Florida State University and added to the Springfield network

SPRINGFIELD NETWORK

230
MILES OF ROADWAY

178
INTERSECTIONS

143
TRAFFIC SIGNALS

1,362
SIGNS

NEW VIRTUAL ASSETS ADDED TO SPRINGFIELD

Springfield is a virtual proving ground used in the NADS-1, NADS-2, and miniSim simulators. The following options were recently added to the Springfield asset library.

Multiple parked vehicles in a row

Yield to pedestrian crosswalk sign, placed in the center of a street

Portable message/DOT construction-style sign, with several options for text

MEDICAL RESEARCH MEETS DRIVING RESEARCH

Does exercise change symptoms and course of Parkinson's disease?

In one of many collaborations with University of Iowa Health Care, NADS is continuing its partnership with neurologist Ergun Uc, MD. In a clinical trial funded by the Department of Veterans Affairs and conducted at the University of Iowa, Uc is leading a study examining the long-term effects of aerobic exercise on movement, cognition, mood, sleep, fatigue, brain tissue, and driving performance in individuals with Parkinson's disease (PD).

The study compares two groups of people with PD over a year-long timeframe: one group that does aerobic exercise (2.5 hours of brisk walking per week), compared to another group that does online health education. Both groups are allowed to exercise as they wish beyond the intervention randomized by the study.

Will exercise improve driving ability in PD patients? That's one of the many questions that Uc's team is hoping to answer. Each subject participates in a baseline driving assessment, which will be followed by another drive one year later. A NADS research vehicle with data collection capabilities has been outfitted with cameras pointed on the subject, on the road ahead, and on each side of the vehicle to determine lane position. Video footage from each drive is analyzed by a blinded certified driving instructor to determine the number and type of driving errors.

NADS Director Daniel McGehee, PhD, a co-investigator in the study, is in charge of the driving component of the project. Cheryl Roe, head of research logistics for on-road vehicles, is coordinating the NADS research effort. She rides in the vehicles with the study subject to monitor the safety of the drive, along with a research nurse from the hospital's Clinical Research Unit. NADS staff have also helped design the route, and they manage and house study data. Uc's research team is looking to enroll around 100 people over the course of the study, which will likely wrap up in 2023.

Details of the study "Long Term Aerobic Exercise to Slow Progression in Parkinson's Disease" can be found at **ClinicalTrials.gov** and **projectreporter.nih.gov**.

Cameras mounted on the exterior of the driver and passenger side doors capture lane position.

"Having NADS expertise doing the driving assessment is a great asset. Driving function is a major outcome of this research, and without NADS here at the university we wouldn't be able to do that. I know with NADS it will be done in a standard, reliable fashion providing a scientific method to evaluate driving. Our partnership has been fabulous."

—Dr. Ergun Uc,
Neurology professor, University of Iowa Health Care, Iowa City VA Health Care System, and director of the Movement Disorders Division and Center of Excellence at University of Iowa Hospitals & Clinics

NEW OPTIONS, INTEGRATION ON MINISIM™

New options for miniSim systems enhance experience, expand research options

The miniSim is a PC-based driving simulator with powerful scenario editing and data acquisition capabilities. The miniSim is ideally suited to academic research and applied research and development applications. Hardware is available in three standard configurations: quarter cab, simplified cab, and desktop. It also supports custom cab and display system designs and user-developed subsystems.

New motion system provides more realistic miniSim experience

New or existing miniSims can now be equipped with a compact low-cost motion system from D-Box Technologies (d-box.com).

Compact, durable actuators installed on the cab frame provide motion cues to the operator in three degrees of freedom (heave, roll, pitch), as well as vibration cues that change in response to road surface type (gravel, concrete, asphalt), vehicle speed, and engine RPM. These cues combine to create a more immersive driving experience for the vehicle operator, and enhance control of the vehicle.

Infotainment systems gaining traction on miniSim

More miniSim clients are opting for an infotainment system for their new or current miniSim, which provides an OEM-style touch interface for tasks other than driving. It is integrated with the scenario control and data acquisition systems, so that the operator's touch inputs are precisely recorded along with driving data.

It also generates a moving map similar to a navigation system and provides audio playback of mp3 files and internet radio stations, simulated phone calls, and other tasks of the user's own design.

Available skins: Toyota Entune and Tesla Model 3 and S

Multi-platform compatibility: Raspberry Pi 3+, Android and iOS, Windows

This miniSim configuration shows an infotainment system and a new D-Box motion system.

miniSim integration launches on D-Lab platform from Ergoneers

In October 2019, miniSim and Ergoneers GmbH launched pre-configuration capability between the NADS miniSim systems and Ergoneers D-Lab platform. This integration makes understanding of complex driving data simpler and more powerful. Simulator data are synchronously recorded with eye tracking data, EEG, heart rate, posture, audio signals, and contextual data, thus providing a more complete data set for analysis in a single workspace.

This integration combines the miniSim's best-in-class driving simulation and scenario control with a system that provides integration of other sensor data in a comprehensive analysis environment.

About Ergoneers GmbH

Ergoneers provides behavioral analysis tools. Their platform enables the use of multiple sensors and data sources to create a cohesive and complete understanding of behavior. For more information, visit **ergoneers.com/en** or email **info@ergoneers.com**.

miniSim™

→ NADS-SC.UIOWA.EDU/MINISIM

80+

MINISIMS IN USE WORLDWIDE

131

MINISIM PROJECTS SINCE 2009

$5,326,648

TOTAL MINISIM FUNDING SINCE 2009

FY20 MINISIM CLIENTS

Colorado State
Loyola Marymount
Oakland University
Penn State University
Texas AMU
University of New Hampshire
University of Washington

SAFER-SIM: EDUCATING FOR SAFETY

Developing future leaders in safety research and simulation is key to SAFER-SIM's work. The center uses webinars, symposia, video series, and other virtual opportunities to share its researchers' expertise with people around the world.

Safety Research Using Simulation (SAFER-SIM) is a grant-funded Tier 1 University Transportation Center that employs simulation techniques to address and promote safety issues prioritized by the U.S. DOT. Led by the University of Iowa, SAFER-SIM is comprised of a multidisciplinary team of researchers across four additional consortium sites: University of Massachusetts–Amherst, University of Central Florida, University of Wisconsin–Madison, and University of Puerto Rico–Mayagüez.

SAFER-SIM supports and 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. They provided funding for 17 new research projects across the country this fiscal year.

→ SAFERSIM.NADS-SC.UIOWA.EDU

IN FY20:

17

NEW RESEARCH PROJECTS FUNDED BY SAFER-SIM

40+

OUTREACH EVENTS AND WEBINARS

5,138

INDIVIDUALS INTERACTED WITH AT OUTREACH EVENTS (PRE-PANDEMIC)

222 + 505

ATTENDEES + YOUTUBE VIEWS OF SAFER-SIM WEBINARS

2

ONLINE SCOUT MERIT BADGE RESOURCES DEVELOPED (TRAFFIC SAFETY AND ENGINEERING)

948

NUMBER OF SCOUTS ACROSS THE COUNTRY THAT HAVE USED THESE SELF-GUIDED RESOURCES

Bettendorf Junior High School visit, Nov. 2019

NEW OUTREACH COMMITTEE

A NADS STEM and Diversity Committee was convened in summer 2020 to plan more virtual STEM outreach activities for K–12 schools across the state, targeting underrepresented students and schools without established STEM programs.

We're currently planning new outreach opportunities such as virtual presentations and demos, and we developed a 360° tour of our facility to share with schools (visit **bit.ly/NADS-360-tour**, available through June 2021).

We're proud to continue participating in and organizing STEM events throughout the state of Iowa to help develop our future leaders.

ATC: PREPARING IOWA FOR AUTOMATED VEHICLES

Spearheaded by the Iowa DOT, the Iowa Advisory Council on Automated Transportation (ATC) is planning a strategic roadmap for the future of automated transportation 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.

Through collaboration and feedback with the ATC, Iowa's Automated Transportation Vision was finalized in March 2020. This document is a roadmap for the ATC and Iowa DOT to progress toward automated transportation with clear strategic direction, sustained programs, and ongoing efforts and activities. You can read it at **iowadrivingav.org/pdf/ATC-Vision.pdf**.

Leaders across the state have been involved in regular committee meetings to discuss topics covering:

- Policy and legislation
- Economic development
- Infrastructure readiness
- Public safety and enforcement

Stakeholder communication has also improved in FY20 with the addition of a newsletter, with plans to expand to a public newsletter in the future.

→ IOWADRIVINGAV.ORG

2019 Iowa State Fair

2019 Johnson County STEM Festival

OUR STUDENTS

We work with students in all phases of their college careers. Some of our graduate students are highlighted on these pages. From graphics design to program development to mechanics to working with research participants, our students are invaluable to our work, and they receive an educational experience that leads to a lifetime of success in a variety of fields.

Hunza Zainab

Q: What brought you to the National Advanced Driving Simulator?

A: An interest in digital signal processing techniques and devising algorithms that help improve quality of life is what brought me to NADS; as automobiles become better and more efficient with technology, we also need to ensure passenger safety, and my work on vital signs detection in a moving vehicle was a step in that direction.

Q: What are you most proud of?

A: I am proud that we were able to come up with an algorithm that would accurately detect the heart rate and breathing rate of occupants of a moving vehicle. This could be groundbreaking as the number of crashes that happen due to drowsy driving and infants suffocating in a closed car will decrease.

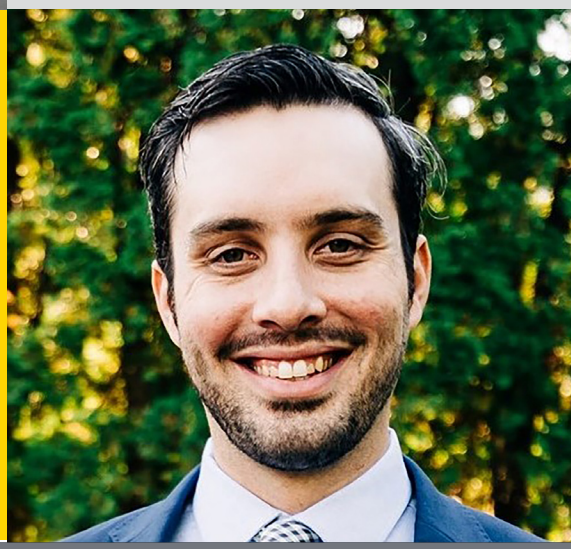
Zach Noonan

Q: What is your research focused on?

A: One facet of my research is developing empirically derived models of human decision-making and risk-perception as it relates to the driving task. Another facet of my research involves using insights gained from human factors analyses blended with systems engineering and social sciences techniques to engineering automated driving systems that don't just act but interact with other road users.

Q: What are the goals of your research?

A: Ultimately, I hope this research will lead to a safer and more efficient mixed automated driving and traffic environment.



Nicole Corcoran

Q: What do you work on and what do you enjoy most about your work?

A: I study the human cognitive experience with advancing vehicle technologies especially as it pertains to autonomous vehicle testing. As vehicle technology advances, I feel it is easy to get caught up in the novel and exciting features of it. What I enjoy most is being able to put the focus back on the needs of the people.

Q: What are your goals for the future?

A: My goals are based on doing good for those around me. If I accomplish anything, I hope that it will benefit the public and make people feel as though their needs are understood. As a human factors engineer, I truly have the opportunity to do that.

Kayla MacDonald

Q: What brought you to the National Advanced Driving Simulator?

A: As an epidemiology student in public health, NADS caught my attention due to their mission to improve road safety. Road injuries are a major public health issue, and by better understanding factors that affect driving, we can work toward safer roads.

Q: What do you work on and enjoy most about your work at NADS?

A: I worked on collecting data for human factors research of partially automated vehicles. I enjoyed experiencing something new each day and gaining a better understanding of data collection and management practices. NADS is a great place to learn and grow as a researcher. The staff are great and support your growth as a student researcher.

Thomas Burt

Q: What brought you to the National Advanced Driving Simulator?

A: After taking a semester off to recover from a car crash, I took Professor McGehee's Autonomous Vehicles course and learned about NADS research. The idea of traffic safety research was especially appealing given my personal experience, and after a fantastic summer internship at NADS, the rest is history.

Q: What do you work on and what do you hope to do in the future?

A: I am doing research on impaired driving and modeling. I hope to get into the automotive industry, applying my interests of coding, design, and statistical analysis.

Christopher Mitropoulos-Rundus

Q: What do you work on and what do you enjoy most about your work at NADS?

A: As a graduate research assistant, much of my research is with electric vehicles. I am researching regenerative braking and how human drivers interact with the new braking system. I am also researching how regenerative braking can be leveraged to assist drivers in emergency braking.

Q: What are your goals for the future?

A: My goals for the future are to earn my PhD in industrial and systems engineering and conduct human factors research for a major automaker.

Emily Shull

Q: What brought you to the National Advanced Driving Simulator?

A: As an undergraduate in psychology, I came across the NADS and realized that my fascination with psychology could be applied to a much broader context, potentially influencing the way we design and implement automation into our lives.

Q: What do you work on and hope to do in the future?

A: My research involves evaluating effective ways of maintaining a user's attention and awareness while in an automated vehicle. Ideally, I would like to continue my research for a broader transportation safety organization that is able to implement guidelines for design and production of automated vehicles.

NEWS BRIEFS

International scholars partner on research projects

Visiting scientists from around the world come to NADS to work on research projects for sometimes months at a time and collaborate with our experts. One such example was in fall 2019, with Felix Ellensohn from the Technical University of Munich, Germany. A PhD research assistant in applied mechanics, he came to NADS to evaluate a motion cueing algorithm (MCA) with the motion simulation of the NADS-1 simulator.

The NADS-1 provides a realistic driving experience, but it is a balancing act to get that simulation experience just right. To the driver, it must feel like they are still moving forward, while the simulator is actually returning to the center of the room in order to stay within its boundary (in a process known as MCA or washout).

The MCA that makes this possible is what Felix was analyzing. His conclusion? He found that the NADS MCA provides a higher motion cueing quality than the one he developed and tested—which provided more evidence that effective motion washout is still something of an art.

Felix Ellensohn, Technical University of Munich (fall 2019)

McGehee joins PAVE Academic Advisory Council

Partners for Automated Vehicle Education (PAVE) selected NADS Director Dan McGehee as one of its Academic Advisory Council members. PAVE is a coalition of industry, nonprofits, public sector entities, and academics with one goal: to educate the public about automated vehicles (AVs).

PAVE's advisory councils are made up of academic experts and public sector officials who believe in PAVE's mission and in the promise AVs offer. They support PAVE's work by providing advice and expertise on matters related to AV technology and its societal effects. See the full list of council members at **pavecampaign.org/advisory-councils**.

NADS hosts international RSS conference

The University of Iowa hosted the Road Safety and Simulation (RSS) conference October 14–17, 2019.

Topics included vulnerable road users, automated and connected vehicles, roadway infrastructure, simulation, distributed simulation, naturalistic driving studies, law, and other topics. Three half-day workshops were offered on automated vehicles, human factors, and simulation boot camp.

The conference program included five panel discussions, 18 lectern presentations, and three poster sessions. Exhibitors included industry stakeholders such as entities that provide research simulator and eye tracking hardware and software.

Attendees toured six research facilities and labs at the University of Iowa including the National Advanced Driving Simulator, Hank Lab, Visual Intelligence Laboratory, Virtual and Augmented Reality Business Unit, 3D Bio-Motion Research Lab, and the Operator Performance Lab. Sponsors included the UI Injury Prevention Research Center and AAA Foundation for Traffic Safety.

RSS 2019

160

ATTENDEES

13 + 27

COUNTRIES + U.S. STATES REPRESENTED

162

TOTAL PRESENTATIONS

6

UNIVERSITY OF IOWA LAB AND RESEARCH CENTER TOURS

Roggentien joins NADS as head of communications

NADS welcomed Kristine Roggentien as their new head of communications in May 2020. She develops communication strategies to inform partners, industry members, the public, and others of our research activities and mission. She is heavily involved in the ADS for Rural America project and virtual STEM outreach activities, provides editing support for various research projects, is planning a new NADS website, and has brought you this Annual Report.

She has 15 years of communications experience in the fields of health care, psychiatry research, and K–12 educational publishing. She can be reached at kristine-roggentien@uiowa.edu.

WHO WE WORK WITH

University of Iowa Faculty Partners

Stephen Baek
College of Engineering
Industrial and Systems Engineering
Visual Intelligence Laboratory

Christopher Buresh
Carver College of Medicine
Emergency Medicine

Venanzio Cichella
College of Engineering
Mechanical Engineering

Jeffrey Dawson
College of Public Health
Biostatistics

Gary Gaffney
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Cara Hamann
College of Public Health
Epidemiology
Injury Prevention Research Center

Joseph Kearney
College of Liberal Arts and Sciences
Computer Science
Hank Virtual Environments Laboratory

Christopher-Rasheem McMillan
College of Liberal Arts and Sciences
Department of Dance

Gary Milavetz
College of Pharmacy
Pharmacy Practice and Science

Corinne Peek-Asa
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Occupational and Environmental Health
Injury Prevention Research Center

Jodie Plumert
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Psychological and Brain Sciences

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Industrial and Systems Engineering

Mark Wilkinson
Carver College of Medicine
Ophthalmology

Xun Zhou
Tippie College of Business
Management Science

External Faculty Partners

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Chengbo Ai
University of Massachusetts–Amherst

Linda Ng Boyle
University of Washington

Eleni Christofa
University of Massachusetts–Amherst

Naveen Eluru
University of Central Florida

Donald Fisher
Volpe National Transportation Systems Center

Cole Fitzpatrick
University of Massachusetts–Amherst

Zhaomiao Guo
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Omer Tatari
University of Central Florida

Lishengsa Yue
University of Central Florida

Didier Valdés
University of Puerto Rico–Mayagüez

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Advanced Brain Monitoring
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AutonomouStuff / Hexagon
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Toyota Collaborative Safety Research Center
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University of Colorado Anschutz Medical Campus
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University of Washington
University of Windsor
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U.S. Department of Homeland Security
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IOWA

College of Engineering