SEMI-ANNUAL PROGRESS REPORT FOR UNIVERSITY TRANSPORTATION CENTERS

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1. Accomplishments

1.1 What are the major goals of the program?

1.1.1 Research

Safety Research Using Simulation (SAFER-SIM) is a Tier 1 University Transportation Center (UTC) with a research priority of promoting safety. The UTC includes five institutions: University of Iowa (lead), University of Wisconsin Madison, University of Massachusetts Amherst, University of Central Florida, and University of Puerto Rico Mayaguez. SAFER-SIM leverages research from a range of disciplines to study how road users, roadway infrastructure, and new vehicle technologies interact and interface with each other. The center uses microsimulation and state-of-the-art human in the loop driving, bicycling, pedestrian simulators to develop solutions for safer transportation in the US and globally.

SAFER-SIM works to promote safety by addressing these research topic areas:

- Automated Vehicles Technology
- Connected Vehicles Technology
- Vulnerable Road Users
- Roadway Infrastructure Design
- Distributed Simulation Technology

1.1.2 Leadership Development

SAFER-SIM sites are recognized nationally and internationally as leaders in transportation safety research with a distinction in applying simulation to safety problems. Developing the next generation of leaders in safety research and simulation is a key function of our work. Our center will accomplish this using seminars, symposia, web-based discussions, and other opportunities to share our expertise.

1.1.3 Education and Workforce Development

SAFER-SIM will educate the next generation of safety professionals, building the transportation workforce for tomorrow, and fostering a vibrant community of researchers.

1.1.4 Technology Transfer

SAFER-SIM will establish and promote opportunities for research collaboration with industry, state and local governments, and other organizations with an interest in transportation safety. The center will promote commercialization activities and will provide highly trained scientists for the industrial work force.

1.1.5 Collaboration

Strong collaboration efforts will take place across consortium sites, within consortium sites, and with government agencies and industry partners. Collaboration plays an important role in reaching goals in all areas at our center.

1.1.6 Diversity

SAFER-SIM is committed to promoting diversity through student involvement on research projects and to reaching underrepresented populations in community outreach.

1.2 What was accomplished under these goals?

1.2.1 Research

The center has funded ninety-nine (99) projects under the FAST Act. Twenty-one (21) projects remain active, and seventy-eight (78) projects have completed research activities. Multi-institution collaborative projects are counted separately for each institution. All project information can be found on the research tab of the SAFER-SIM website and active projects are listed on the Transportation Research Board's Research in Progress (RIP) Database though information is still being gathered for posting for a few projects.

Year	Funded/Inactive	Projects Active	Projects Complete	Total Projects
Y1	0	0	14	14
Y2	0	0	16	16
Y3	0	0	19	19
Y4	0	5	18	23
Y5	0	11	7	18
Y6	0	5	4	9
Total	0	21	78	99

Several research have completed research activities and have submitted reports that are still under review. These projects are finalizing revisions to reports and datasets, and final submission to TRID will follow completion of review.

Below is a summary of research performance metrics for the current performance period. Full list can be found here.

Performance Metric	Result
Peer-reviewed journal publications (published)	13
Book chapters	0
Edited books	2
Conference papers, posters, and symposia	8
Paper/poster awards	0
External grants related to SAFER-SIM	2 awarded 7 submitted

1.2.2 Leadership Development

Researchers and students gained and shared valuable experience through SAFER-SIM work this period.

SAFER-SIM researchers continued representing the center at professional meetings through invited presentations. This work shows the combined expertise of our center along with the wide range of

stakeholders interested in our research including state departments and tech companies. Some invited presentation highlights include:

1. Hamann, C., Reyes, M.L. (2023). Impact of 4-to-3 Lane Road Conversions on Emergency Responses. Iowa DOT Traffic and Safety Forum. Nov. 8. Ames, IA
2. Jaji Pamarthi submitted an abstract and was invited to present a poster describing the research results at the AAAFTS Safe Mobility Conference in Raleigh, NC from March 26-27, 2024.
3. Bhagwant Persaud Webinar, University Toronto Metropolitan University, February 27, 2024.

SAFER-SIM contributed to the advancement of simulation and road safety through other leadership development activities this period. Researchers actively participated on grant review panels, advisory committees, professional organizations, and other scholarly endeavors. SAFER-SIM researchers were honored by an array of awards for impactful achievements in transportation:

1. Jodie Plumert named the Russell B. and Florence D. Day Chair in Liberal Arts and Sciences
2. Shannon Roberts received the Bentzi Karsh Early-Career Service Award from the Human Factors and Ergonomics Society.
3. College of Engineering Outstanding Teaching Award, University of Massachusetts Amherst
4. Ganesh Pai received a Link Foundation Fellowship
5. Anuj K. Pradhan received the AAAM Elaine Wodzin Award

Below is a summary of leadership development performance metrics. Full list can be found here.

Leadership Development Performance Metrics	**Result**
Invited presentations	3
Invited papers	0
Invited workshops	1
Grant review panels	3
Advisory committees	19
Journal editing	39
Leadership positions in professional organizations	17
SAFER-SIM webinars (see section 1.1.4)	3
Professional awards	5

1.2.3 Education and Workforce Development

Consortium members continued engaging students of all levels this period in transportation, safety, and STEM (science, technology, engineering, and math).

Internships

1. SAFER-SIM researchers at The University of Iowa participate in the Workplace Learning Connection internship program. Each term, winter, spring, summer, and fall a SAFER-SIM researcher participates in interviews for internship applicants. Each term over 90 applications are received for internship placement. Workplace Learning Connection then matches applicants with community businesses based on available projects and applicant skills. During this period the Driving Safety Research Institute hosted one high school student intern in the area of computer programming.

2. Meng Wang, a student at University of Massachusetts (UM) is on an internship at Honda Research Institute for Spring 2024.

SAFER-SIM actively engaged K-12 and college students as well as the general public this period through tours, and events. These activities promoted transportation safety and provided career information.
Activities with K-12 students:

1. Career Discovery Tours of Driving Safety Research Institute (58 students) – October 11 & 12, 2023
2. Clear Creak Amana High School students tours of Driving Safety Research Institute (20 students) – October 19 & 20, 2023
3. Iowa City Home School Group tours of Driving Safety Research Institute (25 students) – November 2, 2023
4. Iowa City Home School Group tours of Driving Safety Research Institute (54 students) – February 14 & 16, 2024
5. Shannon Roberts (along with graduate and undergraduate students) gave three (3) tours of the driving simulator lab to prospective UMass undergraduate students.
6. Human Performance Lab Tour as part of the Civil and Environmental Engineering Transportation Seminar Series (led by Anuj Pradhan) (UM) – March 1, 2024

Activities with collage-age students:

1. College of Engineering Career Fair, February 29, 2024 – 731 attendees
2. Tour for Prof. Cari Casteel's class of Driving Safety Research Institute – November 27, 2023
3. Maisha Orthy (prospective grad student) (UI) – February 9, 2024
4. Cornell Engineering Class tour of Driving Safety Research Institute (10 students) – February 23, 2024

Other tours and events:

1. Public Open House Driving Safety Research Institute – (60-80 attendees) – October 18, 2023
2. Alliant Energy tour of Driving Safety Research Institute – January 29, 2024
3. Office of Strategic Communications (OSC) tour of Driving Safety Research Institute and ride in automated shuttle – January 30, 2024
4. University of Iowa Book Club tour of Driving Safety Research Institute – March 6, 2024

SAFER-SIM developed an online resource in 2019 for Boy Scouts of America to earn the Traffic Safety merit badge. The goal of the resource is to create greater visibility and access to the merit badge. The Traffic Safety merit badge "gives Scouts crucial tools to stay safer when driving a car on a highway, riding a bike across town, or jogging across a busy street." By completing the Traffic Safety merit badge, Scouts learn about transportation safety, careers, and research at an opportune time. The online resource continued making nationwide impacts this period with students this period.

In 2020, SAFER-SIM developed a similar online tool for the Engineering Merit Badge. Whether it is improving personal electronics, developing health care solutions, creating automated vehicles, protecting the environment or sending people to Mars, engineers are using math and science to create a better tomorrow. Earning the Engineering Merit Badge gives Scouts a better understanding of how engineers work and how to apply the engineering process to daily problems. For both badges, dome scouts work

with the badge material online then obtain completion documentation locally rather than from our personnel.

Traffic Safety Merit Badge		
	This Period	To Date
Started	57	1221
Completed	39	810
Engineering Merit Badge		
	This Period	To Date
Started	9	355
Completed	5	178

Below is a summary of education and workforce development performance metrics. Full list can be found here.

Education and Workforce Development Performance Metric	**Result**
Peer-reviewed journal publications w/ student authors	10
Book chapters w/ student authors	0
Conference posters and papers w/ student authors	6
Paper/poster awards w/ student authors	0
Graduate students working on and supported by SAFER-SIM related projects	24
Undergraduate students working on and supported by SAFER-SIM related projects	19
Student attendance and presentations at the SAFER-SIM symposium	0
Transportation-related M.A. and PhD theses	1
Curriculum modules developed	2
Student Internships	2
Presentations to student groups or classes	5
# Schools visited and # students present	1 school
# Career fairs visited and # of attendees	1 career fair 731 attendees
Summer institutes and programs and # of students participating	1 program 2 students

1.2.4 Technology Transfer

SAFER-SIM-funded projects work toward technology transfer goals from the beginning through completion. State DOTs, industry partners, and other agencies work with researchers by using their expertise or findings to inform decisions that guide future research and projects.

A main aspect of our technology transfer activities involves webinars. Research projects are required to present webinars about their results which are shared with contacts in academia, industry, and government. The presentations focus on findings, recommendations, specifications, and guidelines. SAFER-SIM uses a combination of webinars from individual project and online symposia where projects may be grouped by subject matter to allow parties interested in specific topics to interact with several researchers and projects in a single session. Attendance at presentations remain open to all transportation professionals and the public, recorded, and posted on the SAFER-SIM YouTube channel so they are available to anyone who was not able to attend or would like to review. Three (3) individual project webinars were hosted this period:

1. 11/7/2023 A Robotic Vehicle Platform for Education and Outreach, Chris Schwarz
2. 11/14/2023 Mapping comprehension of ADAS across the driving and road user population, Justin Mason
3. 12/5/2023 Exploring Impaired Driving, Tim Brown & Cole Kruse

This period was unusual in that no media requests were reported a by SAFER-Sim researchers or directors.

Below is a summary of our technology transfer plan performance metrics with the full list accessible here and more detail provided in Section 3 below.

Technology Transfer Performance Metric	**Result**
SAFER-SIM webinars	3
Registrations for webinars	Not available
Views of archived webinar content	3,071 this period 57,972 lifetime
Press releases for SAFER-SIM related research	0
Media requests	0
Tours of facilities	13
Website traffic	Not available
Patents filed	0
DOT requests for presentations or proposals related to SAFER-SIM	0
Practitioner attendance at in-person events	0 from industry 0 from government
Number of improved or new simulation technologies, software, methods, or processes	0

1.2.5 Collaboration

Collaboration drives our consortium in all aspects of our work. Our collaboration is described further in Section 2 of this report. In this section, we highlight a significant and rewarding collaboration.

The collaborative agreement between SAFER-SIM and AAA Foundation for Traffic Safety was the first of its kind between the foundation and a university or UTC. It was used as a testing ground and template

for future collaborative agreements between the foundation and other institutions and consortiums. Single sentence problem statements were presented to SAFER-SIM researchers who then presented potential methodologies in response. SAFER-SIM and AAAFTS researchers then collaborated to finalize research plans that drew on the expertise of individuals from both organizations.

Six (6) highly innovative research projects were spawned by the SAFER-SIM – AAAFTS collaboration. These projects have advanced understanding of driver's mental models of advanced vehicle technologies, the role of exposure to advanced technologies and the perceptions of other road users, mapped comprehension of advanced driver assistance systems, explored how to enhance the effectiveness of sensory-based alerts, and identified outcome measures to evaluate the effectiveness of consumer education.

The first step was a test of whether SAFER-Sim and AAAFTS had well aligned research goals. The SAFER-Sim project "Extended Evaluation of Training Programs to Accelerate Hazard Anticipation Skills in Novice Teen Drivers" was paired with a proposal the AAAFTS foundation to ensure that research goals and review processes between the two organizations were compatible.

Extended Evaluation of Training Programs to Accelerate Hazard Anticipation Skills in Novice Teen Drivers
Upon beginning independent driving, crash rates among young novice drivers immediately undergo a sharp increase, and then begin to decline quickly with increased driving experience. Recently, the AAA Foundation for Traffic Safety (AAAFTS) sponsored the creation of two training programs designed to accelerate the development of perceptual expertise and hazard anticipation skills in novice teen drivers. We submitted a successful proposal to the AAAFTS to test whether the Perceptual/Adaptive Learning Module (PALM; Lerner et al., 2017) and the Accelerated Curriculum to Create Effective Learning (ACCEL; Fisher et al., 2017) programs accelerate the development of hazard anticipation skills and safe driving behavior in newly-licensed teen drivers. We proposed to use driving simulation to test the effectiveness of the two programs compared to a control group. The goal of the current project proposal is to extend the study period to determine if the hypothesized effects of either intervention persist after six months of independent driving experience. At follow-up, participants will complete another drive in the NADS-2 driving simulator to assess hazard detection and mitigation skills. This work will increase understanding of whether hazard anticipation training programs have longer-lasting impacts on hazard anticipation skills or whether the effects taper off with time and experience. This information will be critical for policy-making decisions on whether to integrate such hazard anticipation training programs into driver education programs for teens.

Leadership from both AAAFTS and SAFER-SIM found the goals and processes well aligned. The process of problem statement – pitching potential methodologies – collaboration on a research plan concluding with funding of a collaborative project was begun and continued each of the four remaining funding years for SAFER-Sim. The second research project within this collaboration examined driver's mental models of advanced vehicle technologies. The project included two phases, the first lead by University of Massachusetts-Amherst and the second by The University of Iowa.

The Impact of Driver's Mental Models of Advanced Vehicle Technologies on Safety and Performance
University of Massachusetts-Amherst Advanced vehicle technologies are increasingly more accessible and available in vehicles. These current and future systems, despite promising added safety, convenience, and efficiency to drivers and road users, have an inherently higher level of complexity than the driving systems that most drivers are used to operating. In order to maximize the promised benefits,

drivers will need to have a good understanding of these systems—referred to as mental models—in order to use them safely and appropriately. Previous research has identified drivers' gaps in knowledge of advanced vehicle technologies. Beyond users' knowledge of a system, understanding and defining a user's mental model is critical for many aspects of advanced vehicle technologies, including the design of, training for, and use of these systems. However, characterizing a driver's mental model is still a significant challenge. Moreover, these gaps and challenges will only be further accentuated with more complexity in vehicle automation, especially with higher levels of automation.

This research was conducted to better elucidate advanced vehicle technologies from a user control perspective, to examine driver interaction with such complex systems, and to characterize driver mental models in this context. This is achieved through: (i) a review of the current state and complexities of one advanced vehicle technology—Adaptive Cruise Control (ACC)—and its associated documentation, (ii) a review and synthesis of existing literature on mental models and error-making, (iii) the development of a task analysis for driver-automation interactions, and (iv) the building of a framework to help examine user interactions with complex systems to identify sources and probabilities of error commission. This document also reports on an examination of the limitations of various ACC systems in the current market in the context of manufacturer's reporting of such limitations.

University of Iowa

Advanced driver assistance systems (ADAS) are rapidly being introduced across automobile manufacturer lineups. These technologies have the potential to improve safety, but they also change the driver-vehicle relationship—as well as their respective roles and responsibilities. To maximize safety, it is important to understand how drivers' knowledge and understanding of these technologies—referred to as drivers' mental models—impact performance and safety. This study evaluated the impact of the degree of accuracy (or quality) of drivers' mental models of adaptive cruise control (ACC) on performance using a high-fidelity driving simulator. Participants with varying degrees of ACC experience were recruited and trained such that they had either a strong or weak mental model.

Participants then completed a study where they interacted with the ACC system and encountered several edge-case events. In general, participants with strong mental models were faster than those with weak mental models to respond in edge-case situations—defined as cases where the ACC did not detect an approaching object, such as a slowmoving motorcycle. The performance deficits observed for drivers with weak mental models appear to reflect uncertainty surrounding how ACC will behave in edge cases. These results raise several important questions surrounding driver introductions to ADAS and the need for training.

The second year of the collaborative agreement continued exploration of advanced vehicle technology, specifically the role of system exposure and perceptions of other road users. This project again included major components conducted at The University of Iowa and the University of Massachusetts-Amherst in collaboration. It also included distribution of a survey across all SAFER-Sim consortium institutions to collect a broader and more representative sample.

Understanding of advanced vehicle technology: The role of system exposure and perceptions of other road users

Drivers often learn about the advanced driver assistance systems (ADAS) on their vehicles over time and through trial and error. While this experience can aid drivers' understanding about the systems, it may not necessarily lead to sufficient and accurate mental models, especially concerning less frequent "edge case" situations. This study recruited 39 new owners of vehicles equipped with ADAS technology to which the owners were naïve. The initial mental model of these owners was evaluated using a mental model assessment. To understand changes in mental models over time the assessment was repeated six times over the course of approximately 6 months. Weekly mileage, technology usage, and information regarding their exposure to edge case scenarios was also collected. At the end of the 6 months, participants completed a simulator drive using adaptive cruise control (ACC) that included several edge cases.

Over the course of the first 6 months of vehicle ownership, drivers' scores on the mental model assessment improved. These improvements were largely due to increased understanding of the technology's limitations as opposed to improvements in knowledge about system function. An evaluation of different clusters of drivers, based on knowledge as well as confidence revealed some important patterns in the evolution of these constructs. With respect to driving performance in the simulator session, the mental model scores were not predictive of responses to the edge cases. However, a comparison of the current mental model scores against weak and strong mental model benchmark scores gathered in a previous study revealed some

additional insight about the role and effectiveness of exposure in mental model development. Overall, the combination of questionnaire, simulation, and naturalistic data used in the current study offers some important insight into how mental models are developed in new owners of vehicles equipped with advanced technology.

The third year of collaboration was a project focused on enhancing the effectiveness of automated vehicle sensory-based alerts. The effort was lead by researchers at University of Massachusetts-Amherst.

Enhancing the effectiveness of automated vehicle sensory-based alert systems

The effectiveness of the human–machine interface (HMI) in a driving automation system during takeover situations is based, in part, on its design. Past research has indicated that modality, specificity, and timing of the HMI have an impact on driver behavior. The objective of this study was to examine the effectiveness of two HMIs, which vary by modality, specificity, and timing, on drivers' takeover time, performance, eye glance behavior, and subjective evaluation. Drivers' behavior was examined in a driving simulator study with different levels of automation, varying traffic conditions, and while completing a non-driving related task. Results indicated that HMI type had a statistically significant effect on velocity and off-road eye glances such that those who were exposed to an HMI that gave multimodal warnings with greater specificity exhibited better performance. There were no effects of HMI on acceleration, lane position, other eye glance metrics (e.g., on road glance duration), trust, or usability. Future work should disentangle HMI design further to determine exactly which aspects of design yield differences in safety critical behavior.

The fourth year of collaboration and the final year of available funding from SAFER-SIM resulted in two independent yet related research projects, one lead by The University of Iowa and the other by University of Massachusetts-Amherst. Both projects continue to advance understanding of advanced vehicle technology. The first by mapping drivers' comprehension of advanced driver assistance systems (ADAS) across the driving and road user population. The second by identifying outcome measures to evaluate the effectiveness of consumer education, which is still ongoing.

Mapping comprehension of ADAS across different driving and road user populations

University of Iowa

Studies have documented gaps in drivers' understanding of advanced driver assistance systems (ADAS); however, there have been few attempts to map knowledge of vehicle technology across different driver characteristics, experiences, and perceptions. Other studies have identified groups of drivers who differ in their knowledge of technology as well as their confidence in their knowledge, including drivers who were lacking in knowledge, but also highly confident. The aims of the current study are as follows:

1. Explore the impact of technology proficiency, confidence, ADAS ownership, personal characteristics and demographics, on drivers' mental models of adaptive cruise control (ACC) and lane keeping assist (LKA).
2. Identify and characterize clusters of drivers based on results from the quality of their mental model of ADAS and their confidence in said knowledge.

The current study employed a national online survey that examined experiences with ADAS, learning preferences, and driving habits from 2,528 participants based on age, race, and gender. Road users' understanding of ACC and LKA were evaluated using mental model assessments. Four distinct clusters (Weak Confident, Strong Confident, Weak Unconfident, Strong Unconfident) of road users emerged, based on road users' mental models as well as confidence in their mental models revealing some important patterns pertaining to their consumer education preferences, use of ACC and LKA, and driving self-efficacy. Findings suggest that road users with a strong understanding of ADAS are younger and preferred relying on videos and the internet to find educational material compared to learning about vehicle systems from the owner's manual or by trial and error. Road users in the strong confident and weak confident clusters reported driving safer and had more positive perceptions of technology. They also reported higher levels of familiarity, trust, and ownership of ACC and LKA systems compared to the strong unconfident and weak unconfident clusters. While experience can aid drivers' understanding about the systems, it may not necessarily lead to sufficient and accurate assessment on how the U.S. population is using ADAS. The current results also underscore the importance of targeted education about vehicle technology.

Identifying outcome measures to evaluate effectiveness of consumer education and training for vehicle automation

University of Massachusetts-Amherst

Auto manufacturers are making advanced vehicle technologies readily available - from current Advanced Driver Assistance Systems (ADAS) to promises of Automated Driving Systems (ADS) (SAE 2018) soon. These technologies are designed to improve convenience and safety (Bengler et al, 2014; Friedrich, 2016). To reap these benefits, it is important that drivers use the systems appropriately, i.e., as intended, during appropriate situations, in appropriate environments, and with clear and accurate knowledge about what the systems can and cannot do. Thus, there is significant interest in examining the impact of advanced vehicle technologies on drivers.

There are multiple contemporary research efforts being undertaken to better understand the benefits, risks, and human factors issues arising from these technologies. One common and critical objective of these undertakings is to better understand how users' understanding and use of the systems can be improved, and what approaches, such as training or education, can help in accelerating users' understanding of vehicle technologies.

Users' knowledge can be examined by studying driver behaviors, driver knowledge, driving outcomes, and other outcome measures. Approaches to do so use methods ranging from survey instruments and driver observations to crash records. While some approaches and methods of measurements may help gauge a user's knowledge, they are not necessarily ideal for studying drivers' actual use of and interaction with the systems. In addition, while crashes are the ultimate measure of safety, they are rare. Identification of measures that can bridge the gap between subjective measures and rare crashes will be essential for understanding effectiveness of training or education interventions.

Below is a summary of collaboration performance metrics. Full list can be found here.

Collaboration Performance Metric	Result
Attendance at the SAFER-SIM symposia	0
Interdisciplinary research projects within and across sites	6
Collaborative research projects across SAFER-SIM or other UTC sites	0
Collaborations with industry partners and government agencies	4
Collaborative peer-reviewed journal publications	0
Collaborative book chapters	0
Student exchanges with other SAFER-SIM sites	0
Students pursuing advanced degrees at other SAFER-SIM sites	0
Programs involving community colleges	1
Graduates hired at other SAFER-SIM or UTC sites	0

1.2.6 Diversity

Diversity continues to play an important part in our research and outreach. The University of Puerto Rico Mayaguez and University of Central Florida are minority serving institutions. Twenty-eight (31) students from historically excluded groups were involved in 22 SAFER-SIM projects this period. Individuals from historically excluded groups contribute to SAFER-SIM at all levels including the directors, advisory board, principal investigators, and students.

No students from underrepresented or minority groups graduated this period.

Below is a summary of diversity performance metrics. Full list can be found here.

Diversity Performance Metric	Result
# SAFER-SIM projects involving underrepresented/minority (U/M) students	22 projects
# U/M events attended	1
# U/M students at attended events	38
Graduating U/M student placement	0

1.3 What opportunities for training and professional development have been provided?
SAFER-SIM provides opportunities for training and professional development in numerous ways. Students gain direct training from faculty and research staff from involvement in research projects. Researchers and students are encouraged to attend conferences to share their work and continually develop their professional skills and share their knowledge with others in the transportation industry.

1.4 How have the results been disseminated?
Final reports and datasets are posted on all required repositories after completion. Additionally, research projects are required to submit two-page summaries and prepare online webinar presentations about their results which are shared with contacts in academia, industry, and government. Researchers and students also share their work at meetings, conferences, and with the public.

1.5 What do you plan to do next reporting period to accomplish these goals?
The center will continue progressing toward final reports from projects. Sites and administration teams have re-organized project timelines after receiving a 12-month no-cost extension. Project symposia will continue as normal.

2. Participants & Collaborating Organizations
2.1 What organizations have been involved as partners?
The following organizations have been involved as SAFER-SIM partners during this reporting period:

Organization Name	*Location*	*Contribution*
1. Grinnell College	Grinnell, IA	Financial support In-kind support Facilities Collaborative research Personnel Exchange
2. AAA Foundation for Traffic Safety	Washington, DC	Financial Support Collaborative research
3. City of Racine	Racine, WI	Financial support to help with the purchase of AV. In-kind support facilities to operate the AV shuttle in Racine.
4. Gateway Technical College	Racine, WI	In-kind support facilities to house and operate the shuttle in Racine.

2.2 Have other collaborators or contacts been involved?
A main focus of SAFER-SIM UTC is collaboration, both within consortium sites and across disciplines. Consortium members have engaged in regular web conferencing, teleconferences, and email

communications, as well as face-to-face interactions via site visits and time set aside during symposia. Site directors participate in a conference call once a month to share information about the progress at each university.

SAFER-SIM researchers have a diverse range of backgrounds that span many colleges throughout the universities. The variety of expertise within the consortium creates a collaborative environment to take a wholistic approach on safety issues. The backgrounds of our researchers include:

- Civil, Environmental, & Construction Engineering
- Mechanical & Industrial Engineering
- Industrial & Systems Engineering
- Computer Science
- Psychology & Brain Sciences
- Public Health
- Management Sciences
- Urban and Regional Planning

Our advisory board currently includes 11 individuals from industry, government, and academia.

William Horrey	AAA Foundation for Traffic Safety
Patrick Hoye	Iowa Governors Traffic Safety Bureau
Rich Romano	University of Leeds
Lisa Schletzbaum	Massachusetts DOT
Gary Huttmann	MetroPlan Orlando
Chuck Green	Industry consultant (formerly GM)
Elizabeth Pulver	State Farm
Don Fisher	Volpe
John Corbin	USDOT
Linda Boyle	University of Washington
Rebecca Burkel	Wisconsin DOT

3. Outputs

Below is a summary of our technology transfer plan output performance metrics. Further description can be found in Section 1.2.4. Technology Transfer Accomplishments with the full list accessible here.

Performance Metric	Target	Result	Target Next Period
SAFER-SIM webinars	10	3	15
Registrations for webinars	100	Not available	200
Views of archived webinar content	200	3,071	3500
Press releases related to	1	0	1

SAFER-SIM			
Media requests	5	0	5
Tours of facilities	15	13	15
Website traffic	3,000 users 3,000 sessions 7,000 pageviews	Not available	1500 users 3000 sessions 3500 pageviews
Patents filed	1	0	1
DOT requests for presentations or proposals related to SAFER-SIM	1 per year	0	1 per year
Practitioner attendance at events	100	0	25
Number of improved or new simulation technologies, software, methods, or processes	1	1	1

3.1 Publications, conference papers, and presentations

Journal Publications

1. Subramanian, L.D., Sherony, R., Plumert, J.M., Kearney, J.K. & O'Neal, E.E. (2024). How Do Bicyclists Respond to Vehicles with Adaptive Headlamp Systems? A Nighttime Study in an Immersive Virtual Environment. Journal of Safety Research, 88, 24-30.
2. Bao H, Zhou X, Hamann C, Spears S (2023). Understanding children's cycling route selection through spatial trajectory data mining. Transportation Research Interdisciplinary Perspectives, 20, July 2023, 100855. https://doi.org/10.1016/j.trip.2023.100855
3. Claros, B., Chitturi, M., Bill, A., & Noyce, D. A. (2024). Naturalistic study of vehicle-bicycle lateral passing distance on high-speed rural two-lane roadways with paved shoulders. Transportation research part F: traffic psychology and behaviour, 102, 316-334.
4. Kim, N. Y., Plumert, J. M., Kearney, J. K., Clark, L. A., Dindo, L. & O'Neal E. O. (in press). Longitudinal and concurrent effortful control as predictors of risky bicycling in adolescence: Moderating effects of age and gender. Journal of Pediatric Psychology.
5. Kruse, C., Brown, T.L., Schmitt, R. Gaffney, G., & Milavetz, G. (Under Review). Assessing the Impact of Cannabis Use on Freeway Driving Performance and Practices: A Comparative Analysis with Placebo and Alcohol-Influenced Driving. Traffic Injury Prevention.
6. Malik, J., O'Neal, E. O., Noonan, M., Noferesti, I., Pixley, W., Plumert, J. M., & Kearney, J. K. Can augmented reality help pedestrians safely cross multiple lanes of traffic? A virtual reality study. Manuscript in preparation.
7. Pai. G., Zhang, F., Hungund, A. P., Pamarthi, J., Roberts, S. C., Horrey, W. J., & Pradhan, A. K. (2023). Frequency and Quality of Exposure to Adaptive Cruise Control and Impact on Trust, Workload, and Mental Models. Accident Analysis and Prevention.
8. Parr, M. D. N., Noonan, M., Noferesti, I., Wang, J., Stoffel, J., Kearney, J. K., & Plumert, J. M. Relations between executive functioning, processing speed, and motor timing in children with

varying movement coordination skills. Manuscript in preparation.
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10. Ryan, A., Ai, C., Fitzpatrick, C., and Knodler, M. (2022). "Crash Proximity and Equivalent Property Damage Calculation Techniques: An Investigation using a Novel Horizontal Curve Dataset." Accident Analysis & Prevention, 166, 106550.
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12. Sarigiannis, D., Atzemi, M., Oke, J., Christofa, E., and Gerasimidis, S. 2024. Feature Engineering and Decision Trees for Predicting High Crash-Risk Locations Using Roadway Indicators. Transportation Research Record: Journal of the Transportation Research Board. DOI: 03611981231217497.
13. Subramanian, L. D., O'Neal E. O., Kim, N. Y., Noonan, M., Plumert, J. M., & Kearney, J. K. (revision under review) Deciding when to cross in front of an autonomous vehicle: How child and adult pedestrian respond to eHMI timing and vehicle kinematics. Manuscript submitted for publication.

Conference papers and presentations

1. Kruse, C., Brown, T. L., Schmitt, R., Gaffney, G., Milavetz, G., & Berka, C. (2024). Effects of Cannabis on Highway Driving Transportation Research Board Annual Meeting, Washington, DC.
2. Miller, R., Hodson, S., Le, T., & Brown, T. (2024). Detection of Cannabis Impaired Driving from Vehicle-based Inputs using Machine Learning Methods. Transportation Research Board Annual Meeting, Washington, DC.
3. Kruse, C., Brown, T.L., Schmitt, R. Gaffney, G., & Milavetz, G. (2024). Assessing the Impact of Cannabis Use on Freeway Driving Performance and Practices: A Comparative Analysis with Placebo and Alcohol-Influenced Driving. Association for the Advancement of Automotive Medicine, Seoul, South Korea. November 2024.
4. Mason, J., Gaspar, J., Carney, C., Romo, A., Kim, W., & Horrey, W. (2024, January). Characterizing clusters of road users based on quality of and confidence in mental models of ACC and LKA. TRB, Washington DC.
5. O'Neal, E.E., Malik, J., Plumert, J.M., & Kearney, J.K. (Sept. 2024). How do Augmented Reality Displays Influence Pedestrian Road-Crossing Decisions in Complex Traffic Environments? Oral presentation accepted to the 2024 World Safety Conference. Delhi, India.
6. O'Neal, E.E., Noonan, M., Yang, G. & Plumert, J.M. (April 2024). Parental Strategies for Training Novice Teen Drivers' Hazard Anticipation Skills. Oral presentation submitted to the 2024 annual meeting of the Society for the Advancement of Violence and Injury Research, Chapel Hill, NC.
7. Arya, M.S., Reyes, M.L., Arabi, S., Sharma, A., Hamann, C. (January 2024). Unsupervised Learning-Based Classification of Driver Following Behavior in Agricultural Traffic. Proceedings of the Transportation Research Board 103rd Annual Meeting. Washington DC.
8. Pai, Ganesh & Pradhan, A.K., (2024). Drivers' Hazard Avoidance Behaviors When Using Advanced Driver Assistance Systems: An Observational Simulator Study, Transportation Research Board Annual Meeting, January 2024, Washington DC

Books or other non-periodical, one-time publications
Nothing to report.

3.2 Policy Papers
Nothing to report.

3.3 Websites(s) or other Internet site(s)
SAFER-SIM website - contains descriptions of research projects and final reports, news articles about our work, contact information, and other important information related to the center.

SAFER-SIM YouTube Channel - contains webinars, virtual symposium presentations, simulation boot camp, and online traffic safety merit badge videos. Metrics from those videos are below:

Metric	This Period	Lifetime
Uploaded videos	3	123
Views	3,071	57,972
Subscribers	262	na

SAFER-SIM Dataverse - data repository containing final data from research projects.

Metric	This Period	Lifetime
Datasets	0	44
File Downloads	na	19,444

3.4 New methodologies, technologies, or techniques
There have been no new methodologies, technologies or techniques reported. Due to the advanced stage of research projects, it is expected that all such reports have been made previously.

3.5 Inventions, patent, and/or licenses
Nothing to report.

3.6 Other products
Simulation Boot Camp Videos –A webinar series developed by the collective expertise of SAFER-SIM to train researchers on using simulation as a research tool. The boot camp was translated into an in-person workshop at the Road Safety & Simulation conference. The five videos in this playlist have 673 views.

Online Traffic Safety Merit Badge –More information in Section 1.2.3.

Online Engineering Merit Badge –More information in Section 1.2.3.

Two-page Project Summaries – Each research project is required to submit a 2-page summary of the research for a quick overview and takeaways from the work. The summaries focus on recommended practices for transportation professionals providing easier access to key information than the technical report and are available on the "Research" tab of our website within specific project information.

Biweekly News Digest – The email campaigns serve to provide information about SAFER-SIM webinars, final reports, conferences, news articles, and job opportunities. Metrics from the news digest are below:

Metric	This Period	Lifetime
Subscribers	345	variable
Campaigns Sent	10	181
# Opens	837	13,336

4. Outcomes

SAFER-SIM included three performance measures related to outcomes in our technology transfer plan:

Performance Measure	Target	Result	Target Next Period
Number of improved or new technologies, software, methods, or processes adopted	1	0	0
Stakeholders who adopt, implement or deploy SAFER-SIM research findings or technologies through policy, practice, regulation, rulemaking or legislation	1	1	1
Number of projects that reach adoption, implementation or deployment	1	0	1

Number of improved or new technologies, software, methods, or processes adopted.
There have been no new methodologies, technologies or techniques reported. Due to the advanced stage of research projects, it is expected that all such reports have been made previously.

Stakeholders who adopt, implement or deploy SAFER-SIM research findings or technologies through policy, practice, regulation, rulemaking or legislation.
Nothing to report.

Number of projects that reach adoption, implementation or deployment.
Nothing to report.

4.1 Increased understanding and awareness of transportation issues

SAFER-SIM makes efforts to reach all stakeholders with our research and outreach. Researchers and students share work at conferences, meetings, and with the general public to promote safety and bring awareness to transportation issues.

4.2 Passage of new policies, regulation, rulemaking, or legislation

Nothing to report.

4.3 Increases in the body of knowledge

SAFER-SIM research continues to build on the knowledge of transportation safety and simulation through final reports, summaries, journal articles, and presentations at conferences, meetings, and other avenues. Full list here.

4.4 Improved processes, technologies, techniques and skills in addressing transportation issues
Highlighted in Section 1.2.4 and in Section 4.

4.5 Enlargement of the pool of trained transportation professionals
Our center supports the development of trained transportation professionals in numerous ways. College students directly involved in research will graduate and join the workforce as members of industry, academia, or government. Outreach efforts focused on middle school and high school students will spark the interest of some to study and join the transportation field. The recorded webinars and presentations from the boot camp continue to draw interest online.

4.6 Adoption of new technologies, techniques or practices
Nothing to report.

5. Impacts
SAFER-SIM included two performance measures related to impacts in our technology transfer plan:

Performance Measure	Target	Result
Expected reductions in crashes from implemented policy, practice, regulation, rulemaking or legislation	Not yet determined	Not yet realized
Expected reductions in congestion and traffic conflicts implemented policy, practice, regulation, rulemaking or legislation	Not yet determined	Not yet realized

Expected reductions in crashes from implemented policy, practice, regulation, rulemaking or legislation.

1. Driver Attitudes and Behavior in the Presence of E-Scooters versus Bicyclists (UM)
    a. This research is expected to set the stage for determining factors and infrastructure design affecting e-scooter safety and understanding how attitudes towards e-scooter riders compare with those towards bicyclists.
2. Evaluation of Driver Workload and Training Strategies on a Diverging Diamond Interchange (UPR)
    a. The reduction in crash potential obtained in the simulation is notable. In the case of direct maneuvers, representing the most remarkable geometric change, the number of instances with critical errors was reduced from (8/48) 17% to (1/48) 2% of the maneuvers performed by the subjects in the study. Potential crashes are associated with critical errors in the different maneuvers performed at the intersection. Critical errors include steering against traffic, stopping in the middle of the road, reversing when realizing a wrong maneuver was made, going off the road, and crashing with curbs or concrete barriers.
    Moreover, the main impact generated by this project is the reduction in the construction costs of the DDI project. In reviewing the design using the driving simulator, important changes were made to the geometry, pavement marking, and signage. New safety features and overhead signs were included that required the installation of structural support for the new signage. These changes were detected in time, avoiding costly interventions that would have been necessary once the intersection was opened to the public. Likewise, the drivers' safety when traveling through this intersection was increased, and, above all, the public's confidence

in implementing innovations to reduce congestion and improve safety. All this was achieved thanks to the simulation experiments done before implementation.

Expected reductions in congestion and traffic conflicts implemented policy, practice, regulation, rulemaking or legislation.

1. Driver Attitudes and Behavior in the Presence of E-Scooters versus Bicyclists (UM)
    a. Reduction of traffic conflicts is expected from implementation of infrastructure treatments and regulations for e-scooter riding that improve safety. Improved safety for e-scooters could motivate increased e-scooter mode share which would consequently reduce congestion.
2. Evaluation of Driver Workload and Training Strategies on a Diverging Diamond Interchange (UPR)
    a. The reduction in congestion, in this case, is mainly due to the implementation of the innovative intersection itself. It is unclear how much congestion was reduced because of the changes generated by the implementation of the SaferSim project and the design process integrating driving simulation to fine-tune the detailed design. However, it was clear that reducing crashes would reduce the non-recurrent congestion generated by such events. In addition, clearer signage and pavement markings made the transition process more straightforward from a Conventional Diamond Interchange (CDI) to a Diverging Diamond Interchange (DDI), reducing congestion.

5.1 Impact on the effectiveness of the transportation system

SAFER-SIM's approach to understanding the role that humans play in a complex, ever-changing transportation environment will lead to improved safety and effectiveness of the transportation system beyond the performance period of the grant. Our research will lead to a safer roadway environment that encourages multiple modes of transportation, thereby also reducing traffic congestion and preserving the environment beyond the performance period of the grant.

5.2 Impact on the adoption of new practices, or instances where research outcomes have led to the initiation of a start-up company

Nothing to report.

5.3 Impact on the body of scientific knowledge

Highlighted in Section 1 and Section 3

5.4 Impact on transportation workforce development

Highlighted in Section 1

6. Changes/Problems

6.1 Changes in approach and reasons for change

There have been no new changes in approach during this period.

The center received a no-cost extension to extend the performance period until September 30, 2024. A no-cost extension was necessary to complete ongoing research projects and to meet our student commitments. As a result, several project timelines were extended. We are working with PIs to complete all projects and finalize all deliverables and reporting materials within the new grant performance period.

All remaining active projects have a performance period that ends on or before June 30, 2024. This will allow time to finalize project deliverables and submit to the appropriate online websites and databases prior to the end of the grant performance period.

6.2 Actual or anticipated problems or delays and actions or plans to resolve them

No problems or delays are anticipated.

6.3 Changes that have a significant impact on expenditures

No changes have had a significant impact on expenditures.

6.4 Significant changes in use or care of human subjects, vertebrate animals, and/or biohazards

No significant changes in use or care of human subjects, vertebrate animals, and/or biohazards have occurred.

7. Special Reporting Requirements

Nothing to report.