

# research review

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## Protecting Rear-Seat Passengers

UMTRI researchers develop and test a suite of advanced restraint systems for rear-seat occupants



Riding in the rear seat of a vehicle is generally safer than riding in the front seat, but the advantage isn't as big as it once was, according to

UMTRI Biosciences researchers.

Associate research scientist Jingwen Hu says that the rear seat of a vehicle accommodates a more diverse range of passengers than the front seat—everyone from infants, toddlers and young teens to seniors. Optimizing occupant crash protection for this wide range of ages and body sizes is a bigger challenge than protecting the adult-sized occupants in front seating positions. Hu explains why.

“Based on the crash injury data for rear-seat occupants, the head is the most commonly injured body region for young children, while abdominal injury is disproportionately high for 6–8 year-old children, and the

chest is most vulnerable in older adults,” says Hu. “These injury trends indicate different injury mechanisms for the wide range of rear-seated occupants.”

And different injury mechanisms require different types of protection. With funding from the National Highway Traffic Safety Administration (NHTSA), Hu and UMTRI colleagues Jonathan Rupp and Matt Reed collaborated with ZF TRW to develop and test a suite of advanced restraint systems for rear-seat occupants.

### Advanced Restraint Systems

Advanced restraint systems include such devices as three-point seat belts with pre-tensioners (which pull the seat belt at the beginning of a crash to remove belt slack) and load limiters (which release webbing gradually during a crash to prevent



excessive loading to an occupant's chest). Load limiters have been widely used in vehicle front seats but are rarely available for rear seats due to the lower occupancy rates. Other advanced restraint systems include four-point seat belts, inflatable belts, roof airbags, and self-conforming rear-seat air bags (SCaRAB), all of which are designs currently focusing on rear-seat occupants.

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# Protecting Rear-Seat Passengers

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In the UMTRI/TRW study, researchers conducted a series of three sled crash tests to establish the baseline performance of the current rear-seat restraint system. The tests also allowed researchers to investigate a variety of advanced restraints and to test the final optimal restraints.

For the sled tests, Hu and his team used four different crash-test dummies—representing a 6-year-old child, small female, medium-sized male, and large male—and subjected them to two crash pulses (soft and severe), selected based on standard NHTSA 35-mph frontal crash tests from 25 small cars. Two impact angles (0° and 15°) were varied in each series of crash tests.

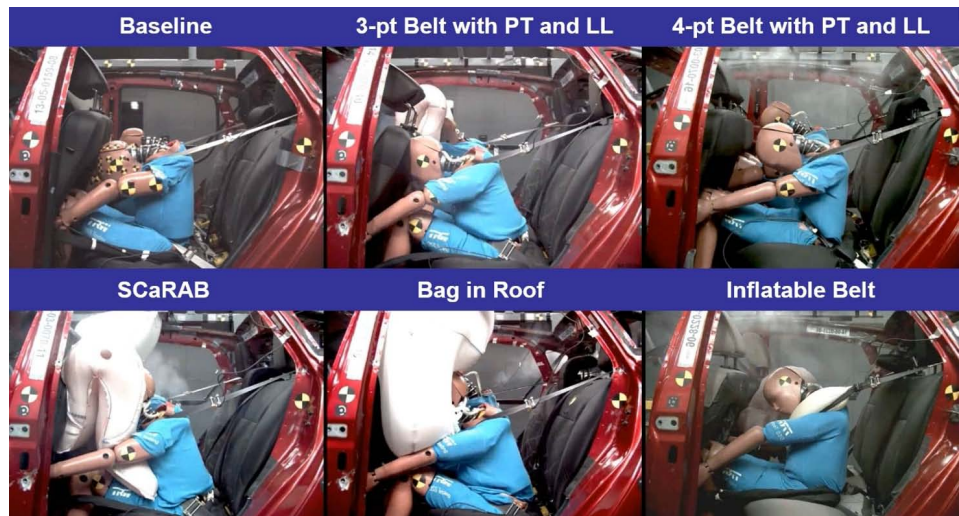
The physical tests in the first two series were used to calibrate sophisticated computational models of the occupants and vehicle. Hu says that once good correlations between the tests and simulations were achieved, he used the validated models to perform design optimizations, or strategies to improve protection for rear-seat occupants of all sizes.

“Computational models can be rapidly ‘crashed’ thousands of times with many different restraint configurations to find the best way to protect occupants,” explains Hu.

## Adaptability is Key Factor

The UMTRI/TRW researchers found that advanced restraints have to adapt to occupant size and crash severity to achieve the best occupant protection. For instance, because field data show that the chest is the most commonly injured body region for rear-seated adult occupants, the researchers attempted to reduce the amount of force impacting the chest while keeping the head from pitching too far forward and impacting the front seat.

Children 6-12 years old, however, have a different problem. Their smaller body size and often slouched posture in vehicle seats can result in poor seatbelt fit and the risk of submarining, or sliding under the seatbelt in the event of a crash.



A series of sled tests shows the baseline performance of the current rear-seat restraint system (top left) as well as performance of advanced restraints including three-point seatbelt with pretensioner and load limiter, four-point seatbelt

with pretensioner and load limiter, self-conforming rear-seat air bag (SCaRAB), airbag in roof, and inflatable seatbelt.

Photo credit: Courtesy of UMTRI Biosciences

**“FINAL RESULTS OF THE CRASH TESTS SHOW THAT THE ADVANCED RESTRAINTS, ESPECIALLY THOSE WITH SCaRAB AIRBAG, CAN SIGNIFICANTLY REDUCE THE INJURY RISKS TO THE HEAD, NECK AND CHEST TO THE REAR-SEAT OCCUPANTS WITH DIFFERENT SIZES AND UNDER DIFFERENT CRASH SEVERITY.”**

In addressing these various injury situations, the UMTRI/TRW researchers found that under the soft crash pulse, an optimal advanced belt-only design (three-point belt with pretensioner and load limiter) met all of the injury criteria; under the severe crash pulse, the advanced seatbelt must be combined with the SCaRAB airbag to meet all of the injury criteria.

Final results of the crash tests show that the advanced restraints, especially those with SCaRAB airbag can significantly reduce the injury risks to the head, neck, and chest to the rear-seat occupants with different sizes and under different crash severity. Hu emphasizes, however, that this study used only a single vehicle model, thus future work is necessary to translate similar results to the whole vehicle fleet.

Still, the UMTRI study demonstrates that properly optimized seatbelts and airbags can significantly improve protection for rear-seat vehicle occupants.

These results are very promising, says Hu, and they come at the right time.

“With the recent popularity of services such as Uber and Lyft, the growing attraction of self-driving vehicles, and the steady increase in the older population in the U.S., rear-seats may become more important than ever before,” says Hu. “Now is a good time to improve rear-seat occupant protection.” 📺



## James Sayer Begins Term as UMTRI Director

James R. Sayer began his five-year term as the director of the University of Michigan Transportation Research Institute on March 1. Sayer replaces Carol Flannagan, who has served as UMTRI interim director during the search for a permanent director.



In addition to his position as director, Sayer is a research scientist at UMTRI as well as adjunct professor of civil and environmental engineering

in the U-M College of Engineering. He is an internationally recognized leader in the conduct and evaluation of field operational



tests of motor-vehicle safety systems and the study of naturalistic driving behavior. Recently, he led the design and development of Mcity, U-M's unique 32-acre full-scale simulated

urban environment for rigorously testing the performance and safety of connected, automated, and autonomous vehicles under realistic, controlled conditions.

"Jim has shown exemplary vision in conceiving innovative interdisciplinary research projects that show the commitment of UMTRI to its mission, and strong leadership in building the relationships with faculty, industry, and government required to make them happen," said S. Jack Hu, U-M vice president for research.

Sayer also served as the principal investigator of the U.S. Department of Transportation's

Connected Vehicle Safety Pilot Model Deployment Program, a \$31 million program to demonstrate connected-vehicle technologies on the streets of Ann Arbor. The results of the Safety Pilot Model Deployment are being used by the U.S. DOT to determine driver acceptance for, and evaluate the feasibility, scalability, security and device interoperability of connected-vehicle technologies. Overall, Sayer has conducted more than \$70 million in basic and translational research in such areas as connected vehicle technology, advanced vehicle safety systems, driving behavior, and driver distraction since 1993.

His work in connected vehicles and the development of Mcity earned Sayer a 2015 White House Transportation Champion of Change award. In the same year, UMTRI observed its fiftieth anniversary.

"UMTRI just celebrated its fiftieth year," said Hu. "I am confident that Jim has the right knowledge, experience, and abilities to lead the organization into its next fifty."

### Associate Directors Named

Sayer recently announced that effective April 1, 2016, Lisa Molnar and Kathy Klinich will serve as associate directors at UMTRI for an initial term of two years.

Associate research scientist [Lisa Molnar](#), Ph.D., who has been with UMTRI since 1986, will be working with, and engaging, schools and colleges on U-M central campus with interests related to UMTRI's. The focus of her effort will be on increasing faculty, undergraduate and graduate student collaborations.

Associate research scientist [Kathy Klinich](#), Ph.D., who has been with UMTRI since 1996, will be working with, and engaging, schools and colleges on U-M north campus with interests related to UMTRI's. The focus of this effort is on increasing faculty, undergraduate and graduate student collaborations. In addition, Klinich will continue to lead UMTRI's initiative on Diversity, Equity, and Inclusion.

Molnar and Klinich replace Lawrence Schneider, whose term as UMTRI associate director ended March 31.

# Advancing Sustainable Supply Chains

UMTRI-SMART conference highlights new-mobility strategies and technologies



UMTRI Automotive Futures and U-M SMART (Sustainable Mobility and Accessibility Research and Transformation)

teamed up February 17 to host a one-day conference on sustainable supply chains. The event highlighted new-mobility strategies and technologies and how they're changing goods movement.

SMART's managing director Susan Zielinski said the movement of goods affects our daily lives—impacting not only the economy, but also the environment and people's quality of life—and yet most people don't think much about it.

“For most of us, goods movement is under the radar,” said Zielinski. “We only think of it when it's not working.”

But lately, plenty of people associated with the supply-chain and freight-movement industries are thinking a lot about innovative solutions, policies, and business models that will make goods movement more efficient, reduce its environmental and social impacts, and offer new business opportunities.

UMTRI's Bruce Belzowski, managing director of the Automotive Futures group, moderated the conference and introduced

speakers representing startup companies and large automotive and IT companies, as well as state and national government representatives and NGOs.

“When we talk about goods movement,” said Belzowski, “it can include anything from raw materials and manufacturing to services and retail, such as consumer products and food, as well as energy technology and distribution, information technology, and infrastructure. It's about anything that moves regionally, nationally, and globally every day, and sometimes it's even about trying to move things less. It involves many modes of transportation including ships, air, rail, trucks, even bicycles and now drones.”

## Maximizing Efficiency, Minimizing Impacts

The supply chain network has become increasingly complex, as new technologies emerge and new players enter the game.

Sophie Punte, executive director of the Smart Freight Centre in Amsterdam, discussed some of the global issues related to sustainable freight movement. She works with industry to remove market barriers, take advantage of existing initiatives, and accelerate the uptake of practical

solutions. One of the challenges, she said, is to understand the landscape. With so many green freight initiatives currently in existence, it's difficult for companies to know which ones to join.

Reducing market barriers to sustainable freight movement is also a major challenge. Globally, freight transport practices differ from country to country—such as large trucking fleets in developed countries and small, owner-operated vehicles in less developed countries that operate on very different budgets. By working with leadership companies first to address common barriers (such as universal emission standards), Punte hopes the solutions will eventually reach the smaller companies.

Thomas Kearney, transportation specialist at the Federal Highway Administration, shared maps of freight movement across the country and highlighted some of the inefficiencies, particularly in transferring between modes in hubs such as Chicago. He also talked about the government's role in public-sector decision-making within the freight industry, which involves building trust and partnering with industry to learn where best to devote public funding.

Cheryl Bynum, who directs the U.S. EPA's SmartWay Transport Partnership, showed how with expanded population growth in developing countries, freight will mushroom. Freight is present at every point of the lifecycle for everything we use, she said, but the global impacts are different across the world. EPA needs to identify solutions to such problems as greenhouse gases and particulates and to implement policies and strategies that mitigate pollution.

She also highlighted disruptive technologies that may change the nature of freight movement, such as mega ships, 3D printing, and IT advancements. However, she said, everything is connected, which creates opportunities but also poses challenges.

“It's important to look at supply chains as a system,” said Bynum. “You can't just improve one area.”



Photo credit: Francine Romine, UMTRI

## New-Mobility Innovations

Komal Anand Doshi, research specialist at SMART and Mobi Platform lead, highlighted some of the disruptive innovations arriving on the freight scene. She gave an overview of several new-mobility companies that employ new business models and technologies to maximize efficiency and minimize environmental impact. They include Trunkbird, Instacart, DoorDash, Bellhops, Shipster, and more.

Other speakers at the Sustainable Supply Chain conference included Mary Wroten of Ford Motor Company; Dave Hoover of Meijer Food Stores; Mike Dargis, president of Zip Xpress, Mike Maceroni and Brian Becker of UPS; and Cherry Burke of Dow Chemical Corporation, all of whom highlighted their company sustainability practices and strategies to maximize freight efficiency and reduce environmental impact.

The sustainable supply chain conference was sponsored by Argonne National Labs, BorgWarner Inc., Bosch Corporation, Denso Corporation, Ford Motor Company, Ford-UAW, ITS America, Oracle Corporation, Valeo Corporation, Zip Xpress, U-M SMART, and UMTRI. It was this year's New Mobility Session, an annual collaboration between UMTRI Automotive Futures and U-M SMART. 📺

## Names & Faces



### TRB 95th Annual Meeting

The Transportation Research Board (TRB) 95th Annual Meeting was held January 10–14, 2016, at the Walter E. Washington Convention Center, in Washington, D.C. A number of UMTRI researchers were among the estimated 12,000 transportation professionals from around the world who attended.

The meeting program covered all transportation modes, with more than 5,000 presentations in nearly 800 sessions and workshops, addressing topics of interest to policy makers, administrators, practitioners, researchers, and representatives of government, industry, and academic institutions.

More than 35 sessions and workshops focused on the spotlight theme for the 2016 meeting, *Research Convergence for a Multimodal Future*, and more than 75 addressed one or more of three hot topics, including transformation technologies, resilience, and transportation and public health.

UMTRI and the U-M Mobility Transformation Center (MTC) hosted a reception on Sunday, January 10, which was well attended by UMTRI and MTC faculty and staff as well as national and international guests from industry, government, and universities.

Throughout the meeting, UMTRI faculty presented research in sessions on transportation network modeling, signal systems, connected-vehicle applications, parking management, young driver behavior, older driver safety, and overseas data sharing. Among the presenters were research professor Henry Liu, assistant research professor Robert Hampshire, associate research scientist Carol Flannagan, research professor Raymond Bingham, and research professor David W. Eby. 📺

### Automotive News World Congress

UMTRI director and research scientist James Sayer participated on a panel addressing connected, autonomous, shared, and electric (CASE) vehicles at the 40th annual Automotive News



James Sayer (right) and fellow panelists discuss connected, autonomous, shared, and electric vehicles at the Automotive News World Congress.

World Congress, held January 12–13, in Detroit, Michigan. CASE describes the bundle of technologies and business models companies may need to stay at the forefront of the industry. Because it is difficult to lead in all four categories, investments are significant and incremental. Panelists discussed how the industry is meeting that challenge and the opportunities it creates. 📺

### SAE Government/Industry Meeting

Understanding how technology, regulations and legislation affect the design of light- and heavy-duty vehicles in terms of safety, environment, and energy conservation is essential to vehicle development. The SAE Government/Industry Meeting, held January 20–21 in Washington, D.C., provided opportunities for technical leaders from government, industry and academia to address issues influencing future decision-making within the industry.

Technical session topics included vehicle crashworthiness, child safety, telematics, compliance, and much more. UMTRI associate research scientist Kathy Klinich presented “Development of Fit Envelopes to Promote Compatibility between Child Restraints and Vehicles.” UMTRI research professor Matt Reed presented on driver head position in the technical session on protecting occupants within the vehicle compartment. UMTRI associate research scientist Jingwen Hu was scheduled to present on rear-seat occupant protection in the technical session on inflatable restraints. 📺

# Recent UMTRI Publications



Most UMTRI reports are available in full text online. See the website address at the end of the citation. Please contact the UMTRI Library at 734-764-2171 or [umtridocs@umich.edu](mailto:umtridocs@umich.edu) to inquire about the availability of other publications listed here.

## Conference Papers

- ▶ Hu, J.; Wood, L.; Orton, N.; Chen C.; Rupp, J.; Reed, M.; Gruber, R.; Scherer, R. 2015. "Effects of Occupant Size, Military Gear, Seatbelt Type, and Advanced Seatbelt Features on Occupant Kinematics in Tactical Vehicles during Frontal Crashes." In *Proceedings of the National Defense Industrial Association Ground Vehicle Systems Engineering and Technology Symposium and Advanced Planning Briefing for Industry*, <http://www.ndia-mich.org/index.php/events/gvsets>
- ▶ Tan, Y.V.; Elliott, M.R.; Flannagan, C.A.C. 2015. "Development of a Real-time Prediction Model of Driver Behavior at Intersections Using Kinematic Time Series Data." In *Proceedings, American Statistical Association, Joint Statistical Meetings*, pp. 3353-3366

## Journal Articles

- ▶ Bärghman, J.; Lisovskaja, V.; Victor, T.; Flannagan, C.; Dozza, M. 2015. "How Does Glance Behavior Influence Crash and Injury Risk? A 'What-If' Counterfactual Simulation Using Crashes and Near-Crashes from SHRP2." *Transportation Research Part F: Traffic Psychology and Behaviour*, vol. 35, November, pp. 152-169.
- ▶ Bingham, C.R.; Zakrajsek, J.S.; Almani, F.; Shope, J.T.; Sayer, T.B. 2015. "Do As I Say, Not As I Do: Distracted Driving Behavior of Teens and Their Parents." *Journal of Safety Research*, vol. 55, December, pp. 21-29.  
DOI:10.1016/j.jsr.2015.07.007
- ▶ Hu, J.; Flannagan, C.; Bao, S. 2015. "Integration of Active and Passive Safety Technologies: A Method to Study and Estimate Field Capability." *Stapp Car Crash Journal*, vol. 59, pp. 269-296.
- ▶ Reed, M.P.; Klinich, K.D. 2015. "Predicting Vehicle Belt Fit for Children Ages 6-12." *Traffic Injury Prevention*, vol. 17, no. 8, pp. 58-64.  
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- ▶ Tan, V.; Flannagan, C.; Rupp, J. Elliott, M. 2015. "Improving Trauma Triage Models for Motor Vehicle Crashes Using Event Data Recorder and Functional Data Analysis." *Journal of Data Science*, vol. 13, no. 2, pp. 637-662.  
DOI:10.1016/j.trf.2015.10.011
- ▶ Wood, L.K.; Miller, C.S.; Madura, N.H.; Reed, M.P.; Schneider, L.W.; Klinich, K.D.; Rupp, J.D. 2014. "Response and Tolerance of Female and/or Elderly PMHS to Lateral Impact." *Stapp Car Crash Journal*, vol. 58, November, pp. 423-463.

- ▶ Xiong, H.; Narayanaswamy, P.; Bao, S.; Flannagan, C.; Sayer, J. 2015. "How Do Drivers Behave during Indecision Zone Maneuvers?" *Accident Analysis and Prevention*, available online July 22, 2015 (corrected proof).  
DOI:10.1016/j.aap.2015.04.023.

## Technical Reports

- ▶ Belzowski, B.; Ekstrom, A. 2015. *Evaluating Roadway Surface Rating Technologies*. Report no. UMTRI-2015-19.  
<http://hdl.handle.net/2027.42/111891>  
The research documented in this report was sponsored by the Michigan Department of Transportation.
- ▶ Klein, K.F.; Hu, J.; Reed, M.P.; Hoff, C.N.; Rupp, J.D. 2015. *Development and Validation of Statistical Models of Femur Geometry for Use with Parametric Finite Element Models*. Report no. UMTRI-2015-37.  
<http://hdl.handle.net/2027.42/116208>  
The research documented in this report was sponsored by the National Highway Traffic Safety Administration.
- ▶ Kostyniuk, Lidia P.; Blower, Daniel F. 2015. *Evaluation of the Records Management System for the Michigan Center for Truck Safety*. Report no. UMTRI-2015-29.  
<http://hdl.handle.net/2027.42/116597>  
The research documented in this report was sponsored by the Michigan Office of Highway Safety Planning.





## UMTRI In The News

### Why it's time to trade in that old car and buy a new one

<http://www.theglobeandmail.com/globe-drive/adventure/red-line/why-its-time-to-trade-in-that-old-car-and-buy-a-new-one/article28781528/>

### Car technology advances can help keep senior motorists safe

[http://www.journalnow.com/news/local/car-technology-advances-can-help-keep-senior-motorists-safe/article\\_581fd1cb-b094-516c-b57f-e9ae907537a6.html](http://www.journalnow.com/news/local/car-technology-advances-can-help-keep-senior-motorists-safe/article_581fd1cb-b094-516c-b57f-e9ae907537a6.html)

### Like millennials, more older Americans steering away from driving

<http://www.npr.org/2016/02/11/466178523/like-millennials-more-older-americans-steering-away-from-driving>

### Fuel-efficient cars: Best way to fight climate change

<http://ns.umich.edu/new/releases/23467-fuel-efficient-cars-best-way-to-fight-climate-change>

### Oil price plunge is good for drivers, but it's a big threat to some clean energy technologies

<http://www.ibtimes.com/oil-price-plunge-good-drivers-its-big-threat-some-clean-energy-technologies-2238787>



## Upcoming Events

### Aging in America Conference

March 20–24; Washington, D.C.  
<http://www.asaging.org/aia>

### Automotive Cyber Security Summit

March 21–23; Detroit, Michigan  
<http://www.automotivecybersecurity.com/>

### Michigan Traffic Safety Summit

March 22–24; East Lansing, Michigan  
<http://www.michigan.gov/mssp>

### Lifesavers National Conference

April 3–5; Long Beach, California  
<http://www.lifesaversconference>

### 2016 AASHTO GIS for Transportation Symposium

April 4–7; Raleigh, North Carolina  
<http://www.gis-t.org/>

### SAE 2016 World Congress

April 12–14; Detroit, Michigan  
<https://www.sae.org/congress/>

### Globalization of the Automotive Industry: The 2016 Update

April 13; Ann Arbor, Michigan  
<http://umtri.umich.edu/who-we-are/research-groups/automotive-futures>

### Transportation and Logistics Council Annual Conference

May 2–4; Albuquerque, New Mexico  
<http://www.tlcouncil.org/>

### Conference on Electric Roads and Vehicles

May 16–17; Logan, Utah  
<http://cervconference.org>

### ITS America 2016

June 12–15; San Jose, California  
[www.itsa.org](http://www.itsa.org)



# Publication Information

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### UMTRI Director:

James Sayer

### UMTRI Associate Director:

Lawrence Schneider

### UMTRI Business Administrator:

Holly Nielsen

### UMTRI Communications and Marketing Director:

Francine Romine

### UMTRI Information Resources Manager:

Bob Sweet

### Writer and Editor:

Joyce Daniels

### Layout and design:

[Graphikitchen, LLC](#)

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Julia Donovan Darlow, Ann Arbor

Laurence B. Deitch, Bloomfield Hills

Shauna Ryder Diggs, Grosse Pointe

Denise Ilitch, Bingham Farms

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Katherine E. White, Ann Arbor

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## UMTRI's Strategic Intent

To be the leader in transportation systems research integrating vehicles, people, and infrastructure to achieve a highway transportation system where:

- ▶ Fatalities and injuries are eliminated
- ▶ People and goods flow efficiently
- ▶ Reliance on nonrenewable energy is reduced