Welcome to the New UMTRI Research Review

No doubt you’ve noticed the new “look and feel” of the UMTRI Research Review. We have updated the format to better reflect our mission of delivering a larger variety of information in each issue. We will highlight UMTRI research projects and personnel, as well as general issues in transportation research. We have also added a section on upcoming events that may be of interest to you.

We have also given our website, http://www.umtri.umich.edu, a facelift and made it easier to navigate its resources. Stop by and see what you find.

We hope you enjoy the updates!

The Many Sides of Driver Distraction

In addition to the myriad of in-vehicle features that can distract drivers, there is also the matter of what is happening outside the vehicle and what is going on inside the driver’s head.

Simply put, driver distraction is any shift of attention away from safe driving, says Fritz Streff, associate research scientist with UMTRI’s Social and Behavioral Analysis Division. He explains, “Essentially, everything that distracts from driving is a potential hazard. Of course, some tasks have benefits that are acceptable. The question is, and no one really agrees, where to draw the line.”

Distraction can be both physical and cognitive, Streff says. “Keeping your eyes on the road is important, but cognitive distraction, when your mind is not on what you are doing, is just as important and dangerous. For example, talking on a cell phone is not just as important and dangerous. For example, talking on a cell phone is not only distracting because of the dialing and holding, but also because talking tends to shift your perceptions and you are ‘looking without seeing.’ Especially in emotionally-laden conversations, drivers are not as conscious of their environment.”

Other cognitive distractions include fatigue, aggression, and mental distraction. Also, drivers tend to misjudge the dangers. “People overestimate their ability to do a lot of things at the same time, and they underestimatethe probability of rare events like traffic accidents,” Kantowitz observes. The problem is that on the road, situations can change from safe to unsafe in the blink of an eye. “I often lapses of attention at the right time can result in tragedy, and major lapses of attention at the right time can be uneventful,” Streff says.

Even under the best scenarios, drivers become distracted by things outside the vehicle such as accidents and construction sites. Sometimes solutions are simple, such as using sheet plastic to mask buildings under construction or screening crash sites. However, all solutions require a balance of efficiency, safety, and cost.

Keeping Drivers’ Eyes on the Road

Streff explores issues related to driver distraction, aggression, and fatigue and makes recommendations to the Michigan State Police. The input is integrated into the planning process for developing the Michigan Office of Highway Safety Planning’s driver behavior safety program. He also works with the local NHTSA representative to develop a plan with the greatest chance of being legislated, based on the latest crash data, political realities, and financial resources.

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**Concentration Lapses and Distraction**

Unlike other car components, such as brakes and power steering, telematics involve human thought processes, and that’s where the danger lies, Kantowitz maintains. Crashes become more likely when drivers lose attention, focus on the wrong tasks, divide attention between too many things, or otherwise become distracted from driving, Streff found.

About 15 percent of crashes are caused by driver preoccupation. “Your mind is on one task, and it takes a while to change over to another task,” Kantowitz says. “So if you’re thinking about some contract negotiation, you may notice something out the window, but by the time you switch your attention to it, you’ve lost a fair amount of time; you’re not aware of things.

**Aggression and Road Rage**

Aggressive driving results from frustration and ranges from being annoying (tailgating, flashing headlights, and honking) to dangerous (saving time at the expense of others by running red lights or weaving out of lanes). Road rage is hostile behavior purposefully directed at other drivers. “Aggressive driving distracts attention from the road to playing mental games with another driver. The focus shifts from driving to exercising their will on someone,” Streff says.

Drivers between the ages of 18 and 25 have the highest aggressive driving tendency, followed by single drivers, and drivers aged 26 to 29. It’s not certain what percent of crashes is related to aggression or road rage, as crime reports don’t include information on the intent of the driver.

A way to alleviate aggressive driving would be reducing the number of frustrations drivers encounter, including reduced road congestion through increased road construction, development and use of alternate routes, and better crime response and clean-up. In addition, radio broadcasts or electronic message signs that provide information about upcoming driving conditions may help drivers set their expectations and lower their frustration.

**Fatigue**

Both fatigue and alcohol use significantly decrease the amount of attention a person can devote to a task. “Tired drivers do not have as many attentional resources and their focus shifts from what they ought to be paying attention to, to what they are actually paying attention to,” Streff says. Fatigued drivers have trouble focusing and are more easily distracted. Fatigue impairs driving ability through increased reaction time and decreased vigilance, attention, and information processing ability. Driver sleepiness causes about 2 percent of all motor vehicle crashes in the United States. As one might guess, sleep-related crashes are more likely to occur at night or mid-afternoon, times when people have a natural propensity for sleep. They are also more likely to involve a single vehicle running off the roadway, to occur on higher-speed roads, and to result in serious injury.

Only one strategy is really effective to combat fatigue. Sleep. Other measures that drivers often use (e.g., rolling down the windows, turning up the radio, or stopping to stretch) are not supported as being truly effective.

**In-Vehicle Telematics**

Another way to look at distraction is to focus on what goes on inside the vehicle. Vehicles now have more telematics features (such as navigation systems, e-mail, paging, and voice mail) that can distract drivers’ attention. “Cars are becoming more like airplanes,” Kantowitz says. “But airline pilots are very highly trained and closely regulated and licensed. Once you get your car driver’s license—and that’s a fairly simple test to pass—you don’t have to go back to school. You don’t have to be certified to use any amount of vehicle information.”

Therefore, researchers have to make telematics as easy and non-distracting to use as possible. Paul Green, a senior research scientist in UMTI’s Human Factors Division and head of UMTI’s Driver Interface Group (http://www.umtri.umich.edu/umtri-driving), says, “There are all sorts of distractions to drivers, but the ones engineers can work to control are those of telematics.” Green leads a team that studies driver workload, navigation, and driver interfaces to assess what people can and cannot do safely. People want new telematics products and companies want to deliver use. With multiple in-vehicle telematics, drivers have to manage input and output, understand and interpret multiple forms of interaction, and process increased information. These tasks have the potential of adversely affecting driver safety unless they are integrated using human factors principles, or workload management, to help people deal with multitelematics.

[Editor’s Note: Watch the next UMTI Research Review for an article on Green’s work with workload managers.]

Roslyn M Illman, NHTSA Deputy Administrator, agrees, “All of those involved in highway safety—whether in government, industry, or the public at large—are responsible for raising and debating the important questions of driver distraction. The highway traffic safety community must expand to include those who design, manufacture, and service the computer, navigation systems, and other devices used on the roads and installed in vehicles.

**The 15-Second Rule**

Unfortunately, the data to make sound decisions about telematics safety and driver distraction doesn’t exist. Green asserts, however, “We can’t wait for crash data to act.” Green has worked as a consultant for the Society of Automotive Engineers (SAE) Human Factors Committee, Navigation Subcommittee to evaluate existing studies and to create two standards (design requirements) based on the results: a procedure for determining whether a telematic device can be used in a moving vehicle and a procedure to calculate its performance. (The latter includes equations for how to time the steps involved in using the device.)

The committee members wanted to develop a standard that would be incorporated into the design of the system, instead of added on later in the process when changes are time-consuming and costly. They considered various ways of defining the standard, from number of menu items to performance criteria, and the logistics of performing their own tests. They discovered it takes 1.2 to 1.7 times as long to perform a telematics task in a moving vehicle than it does in a static car. For measurement purposes, though, it is easier to measure static task time, and then apply the multiplier. Once the mechanics of the study were decided, the committee had to decide on an acceptable task time.

Tasks that drivers are used to performing,
like turning on headlights or windshield wipers, take between three to five seconds. On the other hand, it can take people in a moving vehicle one to two minutes to enter information into visual displays. The committee agreed that three to five seconds was too short and one to two minutes was too long. For guidance on the midpoint, they looked at established practices in Japan, which state that no more than 30 characters (a mixture of Kanji and Roman) can appear on the display. Kanji characters are pictorial, so each character represents a word. After calculating the information content of the Roman and Kanji characters (measured in bits), they computed the equivalent number of Roman characters to express a message that was originally a mixed Roman-Kanji message. Next, knowing the number of Roman characters per word and human reading rates (in words per second), the time to read a 30-character message of both Roman and Kanji characters could be estimated. From there, they deduced that it took 9 seconds to read about 30 Roman characters. Other studies found the same rate to be 9 to 12 seconds. After much deliberation, the committee reached consensus at 15 seconds, and created the 15-second rule (formally known as recommended practice SAE J2364): "Any navigation function that is accessible by the driver, other than functions—zooming in on an electronic map, for example—might be permitted when the car is stopped at a traffic light, but not when it’s moving."

The Science of Driving

By Nancy RosFlanigan, U M N ews & Information Services

I’m cruising down I-94 at 70 miles an hour when a truck in the next lane suddenly cuts in front of me. I draw in my breath, and my foot hovers over the brake pedal.

"It’s okay! It’s okay!" my passenger says. "The car will do it for you."

And so it does. Without my doing a thing, the Chrysler Concorde I’m driving slows down enough to leave a safe gap between me and the truck ahead.

"Whoa!" I gasp. "That was cool!"

While I’m exulting, my passenger is analyzing. The car’s response, the distance between it and the truck, even my hovering foot, all are of interest to Zevi Bareket, a senior engineering research associate with the UMTRI. The car we’re in has been outfitted with an experimental "adaptive cruise control" system, and Bareket wrote the computer programs that control the system.

Like regular cruise control, this system maintains a cruising speed that the driver specifies. But it goes a step beyond, into the realm of "intelligent transportation systems," by allowing me to set a minimum distance between my car and the one ahead. If we start to get too close, my car automatically slows down, braking if necessary, to keep the distance I’ve selected. If the car ahead speeds up or changes lanes, leaving me a long stretch of unobstructed highway, the Concorde automatically speeds up to the cruising speed I’ve chosen.

Systems like these may make life a lot easier for drivers, but they’re also making it a heck of a lot more challenging for engineers. When cars were simpler and slower, engineers considered how drivers responded to certain types of instrument displays or how easily they could operate the pedals, but paid little attention to the minute details of all the things people do while driving. Now, as cars take over more and more of the tasks that drivers used to do, engineers are realizing they need a deeper understanding of just what those tasks entail.

We’re moving from the study of a vehicle as a big hunk of steel with a driver inside to looking at the dynamic system comprising a driver, his or her vehicle and the nearby highway environment. That is, we’re trying to understand how the driver drives, not just what he or she does while driving. Engineers are realizing they need a deeper understanding of just what those tasks entail.

Instead of just looking under the hood, researchers are peeking inside the head of the person behind the wheel. They’re asking questions such as, How does a driver decide when and how much to brake? What cues does the driver use before braking—the sight of a car looming up ahead? the feel of the road surface? a glimpse of motion off to the side? What makes a driver decide to change lanes? How much weaving from one side of a lane to the other is typical?

Cruising in the Concorde with Bareket, another question occurs to me: How does a driver react to a partially automated car that takes over

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The study, a given driver usually fell into the same category—hunter, ultraconservative, flow conformist or planner—whether on or off ACC. The four types used the system differently. Flow Conformists, for instance, used ACC more often and set the system to allow longer distances between their vehicle and the one ahead. Hunters chose the shortest "headway" distance the system would allow but used ACC less frequently overall than did the other groups, possibly because it wouldn’t let them tailgate.

Age was a factor, too. Older people almost never used the ‘close’ setting, young people rarely used the ‘distant’ setting, and middle-aged people normally used the middle setting,” says Paul Fancher, a senior research scientist with UMTRI’s Engineering Research Division who directed the field test.

Like me, many drivers in the UMTRI study had to be reminded not to expect more of the car than it was capable of doing. They tended to use adaptive cruise control “when the world looked benign and there were fewer possibilities,” Fancher says. “But they still did the tough stuff the way they always had.”

I, too, had noticed that some drivers said they liked using the system, and an insight into its appeal came from data collected when they weren’t using ACC. The researchers discovered that in normal driving, drivers press and release the gas pedal far more frequently than anyone would have guessed, and each use registered as a peak and valley on the UMTRI graph of their behavior.

“In an hour there can be a thousand peaks and valleys,” says Fancher. “You can see why this would be fatiguing, even if people aren’t aware of it. With ACC they don’t have to work as hard.”

A bound report nearly an inch thick details the project’s initial findings. One UMTRI researcher already is sitting through it to try to learn whether time of day influences a person’s driving speed and choice of roads. And Sayer is intrigued with the possibility of relationships between personality type and driving style.

When drivers enrolled in the study, they were given the Myers-Briggs Type Inventory personality test, often used in corporate personnel decisions. It classifies people by such factors as how they express themselves, evaluate other people and act on their feelings, and is correlated with scales of aggression, self-confidence and other traits. As far as Sayer knows, no one has ever done a rigorous study relating driving style to Myers-Briggs, but there are clear reasons to take a look. “You’re hearing more and more about things like road rage on the news,” he observes. “You can’t help but wonder if there might be some relationship there.”

Whether the science of driving can help soothe the savage road warrior remains to be seen. But gaining a better understanding of what all of us—hunters, flow conformists, and the rest—can expect of the car is an avenue worth exploring.

H ow A daptive C ruse C o nditi ons W ork s

The adaptive cruise control (ACC) system used in the UMTRI study depends on two infrared sensors to detect cars up ahead. Each sensor has an emitter, which sends out a beam of infrared light energy, and a receiver, which captures light reflected back from the vehicle ahead. The first sensor, called the sweep long-range sensor, uses a narrow infrared beam to detect objects six to 50 yards away. At its widest point, the beam covers no more than the width of one highway lane, so this sensor detects only vehicles directly ahead and doesn’t detect cars in other lanes. Even so, it has to deal with some tricky situations, like keeping track of the right target when the car goes around a curve. To deal with that problem, the system has a solid-state gyro that instantaneously transmits curve-radius information to the sweep sensor, which steers its beam accordingly.

Another challenge arises when a car suddenly cuts in front of an ACC-equipped car. Because the sweep sensor’s beam is so narrow, it doesn’t “see” the other car until it’s smack in the middle of the lane. That’s where the other sensor, called the cut-in sensor, comes in. It has two wide beams that “look” into adjacent lanes, up to a distance of 30 yards ahead. And because it ignores anything that isn’t moving at least 30 percent as fast as the car in which it is mounted, highway signs and parked cars on the side of the road don’t confuse it.

Information from the sensors goes to the Vehicle Application Controller (VAC), the system’s computing and communication center. The VAC reads the settings the driver has selected and figures out such things as how fast the car should go to maintain the proper distance from cars ahead and when the car should release the throttle or down-shift to slow down. Then it communicates that information to devices that control the engine and the transmission.
Multi-Disciplinary Investigation of Real-World Crashes

Larry Schneider, head of U MTRI’s Biosciences Division, and the U MTRI crash-investigation team are working with the University of Michigan’s Trauma Burn Center to form the UM Center of the Crash Injury Research Engineering Network (CIREN). CIREN is a relatively new multi-disciplinary crash-investigation program funded jointly by NHTSA and the auto industry. The UM CIREN center is one of nine trauma-based CIREN centers throughout the U.S. Unlike most crash investigation programs, CIREN crash investigations are initiated by a patient who is admitted to a level-one trauma center as a result of a motor-vehicle crash. Cases are selected for investigation based on preliminary information about the patient’s injuries, the type and severity of the crash (from EMS reports), and the vehicle model year. If the crash fits the study criteria and the patient or family member agrees to participate in the study, U MTRI investigators spring into action to find, measure, and photograph the involved vehicles and the crash site. Detailed information, plus digital images of the vehicle exterior and interior, are later examined at monthly case review meetings, along with detailed information, photos, and medical images. Using the combined input of medical, EMS and rescue personnel, biomechanical engineers, crash investigators, and auto safety experts, an effort is made to determine the sources and mechanisms of injuries to the trauma patient, and to evaluate the performance of the latest safety technologies. “The more details you have about the crash and the resulting injuries, the better chance you have of figuring out what caused the injuries,” Schneider says. The CIREN cases are unique in this regard, because they include medical images showing details of internal injuries, and often photographs of external injuries that can be useful in determining exactly what the occupant contacted and how a body part was loaded or deformed.

Pregnant Occupants and Fetal Loss in Motor-Vehi cle Crashes

Biomechanics researchers in the Biosciences Division are also working with Dr. Mark Pearlman, UM professor of surgery, and obstetrics and gynecology, on several projects related to fetal loss in motor-vehicle crashes. The researchers have been investigating motor-vehicle crashes involving pregnant occupants, as well as studying the anthropometry of the pregnant driver and the location of the pregnant abdomen and fetus in relation to the steering wheel and belt restraints. The studies have provided information and data needed to design a new pregnant crash test dummy called M ama2B (short for M aternal Anthropomorphi c M easurement Apparatus—Version 2B). The projects also involved James A. Ashton-Miller of the U M College of Engineering, and Steve M os and Jennifer Zhou of First Technology Safety Systems, the leading crash dummy manufacturer in the United States. The new pregnant dummy has been designed to assess the likelihood of fetal loss due to separation of the placenta from the uterus (abruptio placenta), which is reportedly the leading cause of trauma-induced fetal death.

Human Motion Modeling

Matt Reed, an assistant research scientist in U MTRI’s Biosciences Division, is working with the U M Industrial and Operations Engineering (IOE) department on ergonomic studies relating to vehicle occupants. Dr. Reed is working with the Laboratory for H uman M o tion Simulation (HUM OSM), which is part of IOE’s C ener for Ergonomics. The HUM OSM laboratory studies and models human motion to improve the design of vehicles and workplaces. HUM OSM has recorded over 30,000 whole body motions from operators in vehicles and industrial settings. Statistical models created from these data provide realistic human movement predictions for tasks ranging from driving cars and trucks to manufacturing and assembling complex equipment. Injuries caused each year as the result of over-exertion—strains from lifting, reaching, pushing, and pulling—cost billions of dollars each year in lost wages and medical bills. So designing ergonomically friendly environments, such as vehicle interiors and office space, makes both people and bank balances more comfortable. But such design also requires extensive and accurate human motion data, much of which does not yet exist. “The best way to provide this is to fuse computerized modeling with real human movement data,” says Prof. D on Chaffin, director of the HUM OSM lab. “Providing the designer or engineer with lifelike computer images of various people, and giving them the means to easily depict many different movements, enables early and fast evaluation of new designs to assure their compatibility with intended user groups.” Principal investigators on the project include Dr. Reed; Prof. Chaffin of Industrial and Operations; Prof. Julian Faraway, from the Department of Statistics; and Prof. Bernard Martin of Industrial and Operations Engineering.

The team plans to develop statistical functional regression analyses to use in predicting 34,000 existing motions, and create software versions of the motion models. They will also perform empirical motion

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studies to investigate:

- Complex grasping of objects required to reach into vehicles for maintenance or assembly
- Leg-foot motions needed to operate mid- to large-pedal trucks
- Reach and motion capabilities of people with spinal cord injuries and chronic lower back pain
- Seated and standing reaches needed to determine the exertion levels that define functional maximum reach capabilities.

Dr. Reed, who is involved in the latter investigation, says, “We will be modeling reach envelopes—that is, how far the average person can reach, or how difficult it is for a population of drivers to reach various controls in a vehicle, such as the radio or navigation system. U M T R I brings expertise in automobile and heavy truck ergonomics to the collaboration with H U M O S I M, which has extensive experience in human motion measurement and modeling.”

Vehicle Thermal Management Systems Conference and Exhibition
May 14–17, Nashville, TN

Sixth Annual Michigan Traffic Safety Summit
May 15–16, Grand Rapids, MI
http://www.ochsp.state.mi.us/summit/summit2.htm

Accident Reconstruction TOPTEC: Special Topics
May 22–23, Tempe, AZ
http://www.sae.org/calendar/toptec2.htm

Fundamentals of Sensor Design for Automotive Air Bag Systems
June 4, Troy, MI
http://www.sae.org/contedu/

17th International Technical Conference on the Enhanced Safety of Vehicles
June 4–7, Amsterdam, Holland

ITS2001, Intelligent Transportation Society of America's 11th Annual Meeting and Expo
June 4–7, Miami Beach, FL

2001 Global Powertrain Congress
June 5–7, Detroit, MI

Canadian Multidisciplinary Road Safety Conference XII
June 10–13, London, Ontario, Canada
http://www.cyberus.ca/~crsp/cmrs2.htm

EnV 2001: Global Solutions for Sustainable Mobility
June 10–13, Southfield, MI
http://www.ed.org

Braking Performance of Heavy Commercial Vehicles
June 18–19 or Sept. 10–11, Troy, MI
http://www.sae.org/contedu

EAEC 2001:
European Automotive Conference
June 18–20, Bratislava, Slovakia

Testing Expo 2001
June 19–21, Stuttgart, Germany
http://www.testing-expo.com

National Symposium on Transportation: Innovations in Transportation Education and Workforce Development
June 21–22
U.S. DOT Volpe Center, Cambridge, MA
http://www.volpe.dot.gov/outreach/symposium/1.html

Work Zone Traffic Control
June 21–22, Chicago, IL
http://www.asce.org

Vehicle Dynamics for Passenger Cars and Light Trucks
June 25–27, Troy, MI
http://www.sae.org/calendar/semdyn.htm

Digital Human Modeling for Design and Engineering
June 26–28, Arlington, VA
http://www.sae.org/calendar/dhm/index.htm

2001 Great Lakes International Rural Intelligent Transportation Systems Conference
June 27–28, Kalamazoo, MI
http://www.mdot.state.mi.us/conference/ruralit/

Current Issues in Using Crash Injury Data
June 28, Troy, MI
http://www.sae.org/contedu

Fundamentals of Seat Ride Dynamics
June 28–29, Troy, MI
http://www.sae.org/calendar/sempart.htm

31st International Conference on Environmental Systems (ICES)
July 9–12, Orlando, FL
http://www.sae.org/calendar/ices/index.htm

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Interesting Facts About Transportation Safety

• In 1895, five years after the first autos are manufactured, the only two cars in Ohio crash into each other. One driver dies, becoming one of the first known motor-vehicle fatalities.

• In 1922, auto fatalities reach 14,859 or almost 22 per 100 million vehicle miles (the rate today is about 1.7).

• In 1924, President Herbert Hoover convenes the first national conference on street and highway safety.

• The U.S. has 46,564 miles of interstate highway, 113,995 miles of other National Highway System roads, and 3,771,456 miles of other roads.

• Nationwide, school bus accidents are most likely to occur on Tuesdays (21.2 percent) and accidents involving other kinds of buses are most likely to occur on Fridays (20.2 percent).

• Angle collisions (38 percent) are the most common type of bus accidents and usually occur at intersections.

• Most households (42 percent) have two vehicles, while 6 percent have no vehicle, 31 percent have one vehicle, and 21 percent have three or more vehicles.

• In 1999, 34,519,136 vehicles entered the U.S. from Canadian borders, and 83,638,656 vehicles entered the U.S. from Mexico.

• The average household spends about 20 percent of its income on transportation expenses.