UMTRI
RESEARCH REVIEW

Transportation Tidbits

- The first organized automobile race, the Paris-Rouen Reliability Trial, took place in France on June 22, 1894. Most of the 102 vehicles were powered by gas or steam, though a few used springs, electricity, and compressed air. After elimination trials, twenty-one vehicles ran the 78-mile course. The winner, a DeDion steam tractor that pulled a carriage, clocked an average speed of 12 mph. ❯

- On June 10, 1947, Saab introduced its first car, the model 92 prototype. Prior to that time, Saab had primarily produced military aircraft. With the end of WWII, however, company executives realized the need to diversify the company's production capabilities. After a thorough planning campaign that at one point led to the suggestion that Saab manufacture toasters, company executives decided to start building motor cars. [n]

- On June 30, 1953, the first Chevrolet Corvette was produced in temporary facilities in Flint, Michigan. The Corvette was born as a dream car for the 1953 Motorama. The first all-fiberglass-bodied American sports car, the white convertible roadster with a red interior turned heads with its release. [n]

- On May 16, 1956, General Motors dedicated its brand-new, $125 million GM Technical Center in Warren, Michigan. The Center was designed by GM president Alfred Sloan and Harley Earl. Earl also designed GM's 1927 LaSalle, the first production car to offer a sleek, long, and rounded look. [n]

- On April 2, 1987, the U.S. Government allowed individual states to increase the speed limit on rural roads from 55 to 65 mph. Over the next ten years, legislation would dramatically increase the speed limits observed on our country's roads. [n]

- On July 16, 1909, Audi was founded by August Horch in Germany. He originally called the company Horch Automobil-Werke, but had to change it due to a legal dispute. He decided on Audi as it's the Latin translation of Horch (the German word for *hark*). ⊕

Sources

❯ *On the Move: A Chronology of Advances in Transportation* by Leonard C. Bruno

[n] This Day in Automotive History, www.historychannel.com

⊕ An Overview of Audi Tradition, www.audi.com

Researchers from UMTRI, Visteon Corporation, and Assistware Technology are developing and testing a new technology that could prevent a large portion of run-off-road crashes each year. Such crashes account for 40 percent of traffic fatalities or about 15,000 persons killed each year in the United States. The road departure crash warning (RDCW) field operational test (FOT) is sponsored by the U.S. Department of Transportation as part of its Intelligent Vehicle Initiative program, which seeks to promote new automotive products that will help drivers avoid crashes.

ROAD DEPARTURE CRASH WARNING FIELD OPERATIONAL TEST

By means of a scientific experiment using members of the driving public, the field test will support a real-world assessment of the RDCW system's:

- safety benefits
- driver acceptance
- performance and capability
- market potential and pricing acceptance

The RDCW system has been built into a fleet of 11 passenger vehicles (all four-door Nissan Altima sedans). Baseline driving data is collected in the first week of the field test, without the system being activated for use by the driver. Beginning the second week, the RDCW system becomes available to the driver for the remainder of the driving period. In early May, the first set of subjects gained access to the test vehicles for a month of personal use.

UMTRI's participation in this study is led by research professor Robert Ervin, together with coprincipal investigators James Sayer (leading the human factors research) and David LeBlanc (leading the engineering research). UMTRI is the prime contractor to the U.S. DOT and is responsible for designing and conducting the field experiment. Visteon, a major international automotive supplier headquartered in Dearborn, Michigan, has developed and built the RDCW system with the help of its partner, AssistWare Technology of Wexford, Pennsylvania. The total project cost amounts to $20.5 million in government and industrial funds.

The RDCW system provides two distinct modes of driver warning that are designed to minimize nuisance and gain credibility with the driver for the time when a road departure warning is truly needed. The first type of warning is to prevent the drift-off-road problem that arises from inattention or drowsiness. A second type of warning is to alert a person who is driving too fast for an upcoming curve. Both functions provide warnings only, and do not intervene in vehicle control.

LATERAL DRIFT WARNING

The lateral drift warning (LDW) function alerts a driver whose drift-off path poses a crash risk. Such crash threats include the possibility of collision with another vehicle or a fixed object or, perhaps, a rollover on the irregular contour of roadside terrain. LDW provides audio, visual, and seat vibration warnings when it detects drift-off.

If drifting from their lane, drivers receive either a cautionary or imminent alert, based on lane position, lateral movement, and the type of lane boundary. A cautionary alert occurs when the driver crosses a dashed-line boundary with no vehicles in the drift path. The alert appears as a yellow icon on the dashboard display and as a vibration on the left or right side of the driver's seat, depending on the direction of lateral drift. An imminent alert occurs when the driver approaches

or has crossed a solid-line boundary or when crossing a dashed-line boundary while a vehicle or other object is present in the drift path. A red icon appears on the display and a buzz sounds on the side of the vehicle at which the threat is developing.

LDW becomes inactive in the following conditions: on unpaved roads, on roads with poor lane markings or badly defined road edges, and at speeds below 25 mph. LDW automatically turns off when drivers engage the turn signal so that they can change lanes without receiving a warning.

The LDW system processes data from a forward-looking video camera to measure vehicle position and lateral velocity relative to lane and road-edge markings to assess the threat of lateral drift departure. This function goes beyond simple lane-departure warning by using radar to help assess the room that is available on the shoulder for performing a recovery maneuver. When ample room is present, warnings are delayed to avoid nuisance alarms that often result from early warnings. However, when little room is available, the warnings are given early so that the driver has enough time to respond and avoid a crash.

CURVE SPEED WARNING

The curve speed warning (CSW) function alerts drivers if they are traveling too fast to successfully negotiate an upcoming curve. The CSW function uses global positioning system (GPS) data and a precise, on-board map database to determine the current vehicle position, the most likely future path, and the geometry of the road along that path. A CSW alert is issued when, based on the current vehicle position

and speed, a substantial level of braking would be needed to achieve a safely-controllable speed in the curve ahead.

Drivers receive either a cautionary or imminent alert, based on the degree of overspeed and their remaining distance to the curve. A cautionary alert indicates that a modest degree of braking is needed to avoid overspeed on the curve. The alert appears as a yellow icon on the display and as a vibration at the front of the driver's seat. An imminent alert indicates that a relatively high level of braking is required to avoid a run-off-road collision. A large red icon appears on the visual display and a voice warning says "Curve! Curve!"

CSW becomes active at speeds above 18 mph as long as GPS satellite tracking and map database coverage are available. Most of the field-test driving area (southeastern Michigan) is well mapped and supports CSW availability for approximately 90 percent of all miles driven. The system uses the turn signal and other cues to determine whether an upcoming exit ramp, or any other roadway branch, is likely to be the driven path.
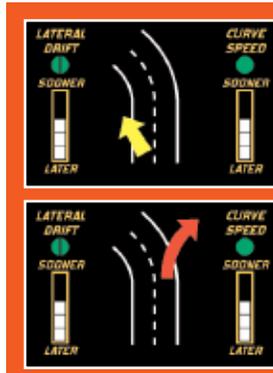
Cautions and warnings for both lateral drifts and curve speed are displayed on an LCD in the car's instrument panel.
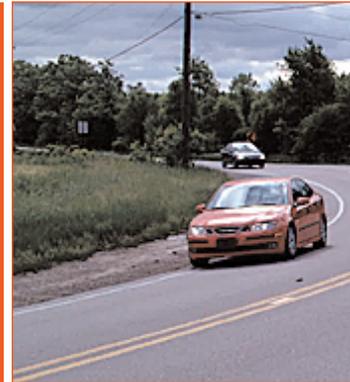
COMPONENT SUBSYSTEMS

Several subsystems are used in tandem with the LDW and CSW systems. Each of these subsystems is described below.

Situation Awareness Module

A situation awareness module (SAM) analyzes data to determine the current maneuvering room available to the vehicle. The SAM can estimate the width of paved shoulders (under favorable imaging conditions) and the locations of objects on the roadside and in the adjacent lane. It can distinguish between permanent and temporary
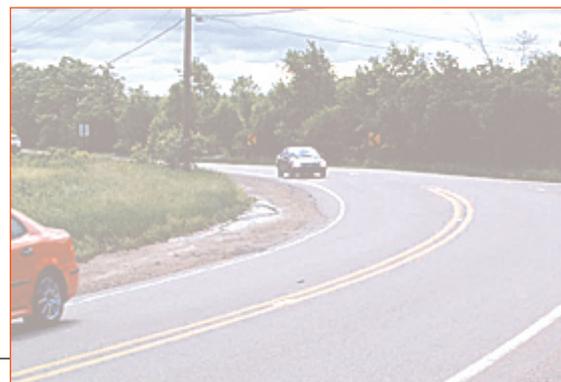
objects that decrease usable shoulder width.

The SAM integrates data from various sensors and processors to create data structures that describe the local environment and subject vehicle.

Data collected for the local environment includes:

- upcoming road curvature
- lane width
- paved shoulder width
- boundary marker types
- number of lanes
- temporary roadside objects such as parked vehicles
- permanent roadside objects such as bridge abutments

Data collected on the subject vehicle includes:

- lateral offset from lane centerline
- yaw angle
- speed
- lateral and longitudinal acceleration

- brake and accelerator pedal positions
- turn signal indicator
- wiper state (on, off, setting)
- headlamp state (high beam, low beam, off)

The SAM plays two major roles in the RDCW system: It acts as a central repository for all data produced by other RDCW subsystems, and it fuses all sensor information into a geometric understanding of the environment around the vehicle. As a central repository and clearinghouse, the SAM receives data from one sensor or subsystem and sends it to a destination subsystem. For example, the SAM relays the following kinds of information: the lane boundary type from the LDW system to the CSW system, turn signal and brake status from the vehicle's controller area network bus to both the LDW and CSW systems, and all relevant information to the data acquisition subsystem. Situated as an information relay module, the SAM also monitors the health of all sensors and subsystems, and reports a failure if it has not received data for some time.

The SAM also fuses all sensor information it receives (such as GPS, gyro, radar, path information, vehicle information, and lane and road information) into a cohesive geometric understanding of the environment around the vehicle. By locating objects (such as parked vehicles and guardrails) relative to the vehicle's travel lane, the SAM estimates the

Much of the hardware needed for the lateral drift and curve warning systems is housed in the trunk of the test vehicles. The equipment is hidden behind a panel that subjects are asked not to remove.

available lateral maneuvering room on either side of the vehicle. It sends this information to the LDW so it can dynamically adjust its lateral drift warning thresholds.

The SAM also stores relevant information to recompute the available maneuvering room in a database. This "look-aside" database is used on subsequent traversals of the same roadway to afford a higher-fidelity rendering of the roadside constraints. This database, in combination with the forward-looking radar sensors, allows SAM to estimate the available lateral maneuvering room for approximately 4 seconds into the future of the vehicle's travel (the actual distance depends on the vehicle's current speed).

Radar Subsystem

The radar subsystem contains two forward-looking and two side-looking radars. The forward radar is aimed to

detect road-side objects ahead of the vehicle that may constrain the maneuverability room that will be available along the projected future path. The side radar detects shoulder-width-reducing objects at the moment that they are adjacent to the vehicle. It also refines the location of objects that were detected moments earlier by the front radar and designates them as permanent or temporary objects.

The forward-looking radar sensors can detect objects that lie ahead of the vehicle but along the roadside. The sensors communicate information to the SAM on the range and azimuth angle of forward objects like parked vehicles, trees, and bridge abutments. The SAM uses this data to calculate the lateral offset of each object from the projected lane edge so as to estimate the future available maneuvering room.

The side-looking radar sensors measure the lateral distance from the

vehicle to objects directly adjacent to the vehicle (including other vehicles on the roadway, guardrails, and other roadside structures). The SAM uses this information to estimate current available maneuvering room to each side of the travel lane, as well as to refine the position and offset of objects detected by the forward radar for subsequent designation as a static object and population into the look-aside database.

The radar sensors, situation awareness module, lane-tracking subsystem, GPS, and digital map all work together to create a knowledge representation of the vehicle and its surroundings. A warning arbiter will use this representation to determine whether to issue an alert. In particular, the arbiter compares the urgency of simultaneous warrants for both lane-drift and curve-speed warnings and issues the more urgent of the two messages.

Driver-Vehicle Interface Subsystem

The DVI subsystem provides the driver with a unified, consistent interface to the roadway-departure countermeasure. Its first role is to arbitrate between road departure and curve-speed warning signals, based on the severity of each threat, to avoid driver overload and confusion.

The DVI display—located on an LCD in the car's instrument panel—presents status information and warning messages. It controls the vehicle's audio system by adjusting the volume from the radio commensurate with the ambient noise level to ensure that the warning is always audible. The DVI also controls the seat vibration warnings. The DVI displays the sensitivity levels selected by the driver for triggering cautionary and imminent warnings in relation to the respective CSW or LDW threat conditions. A display is also provided to indicate whether the LDW and CSW functions are currently available for converting a threat condition into an alert.

Data Acquisition Subsystem

The data acquisition subsystem (DAS) collects more than 300 channels of data every tenth of a second throughout the field test. The data includes vehicle speed, lane position, location of lane and road edges, and any objects in the proximity of the vehicle, plus many signals indicating the driver's actions and the state of vehicle control. Data is gathered from radar sensors pointing in front of and to both sides of the vehicle, by video cameras pointed through the windshield and at the driver's face, and by means of several other instruments that monitor the motion of the vehicle and whether a cell phone is in use. A comment button, installed in the dash-

board, allows drivers to provide an audio record of their comments and reactions any time they drive.

The DAS automatically sends a data sample from the vehicle to the UMTRI facility, via a cell modem, each time the ignition is turned off. These data samples are continually monitored by UMTRI staff to ensure that the test system is functioning well and that the vehicle is not being abused in service. Finally, when the vehicle is returned to UMTRI at the conclusion of a subject's driving period, a hardwire connection is made to an ethernet port on the DAS, whereupon the full contents of the DAS hard disk are transferred onto a large server. The DAS also has manual interaction modes to download new code, manually enter data (e.g., to identify each new test driver), and revise metadata that document the DAS software configuration and all the data channels.

DESIGN OF THE EXPERIMENT

Test subjects for the field operational test are recruited from among licensed drivers in Michigan, by means of a random sample of registration records on file with the Michigan Secretary of State. The candidate drivers, all from southeastern Michigan, receive postcard invitations to participate in the study. The selected driver sample is composed of three groups of twenty-six persons each who are in their 20s, 40s, or 60s, including equal numbers of men and women in each age group. Each qualifying subject is given an extensive orientation on the system before being given one of the test vehicles to use for a month as their personal car.

Over a ten-month period, a total of seventy-eight individuals will have driven the vehicles and participated in the debriefing process at the end of the

The curve speed warning system uses global positioning system (GPS) data and a precise, on-board map database to determine the current vehicle position, the most likely future path, and the geometry of the road along that path. The GPS antenna is visible on the test vehicle's trunk.

drive. In addition to an extensive post-drive questionnaire, the subjects are asked to review the "playback video" from several examples of their experience with RDCW alerts, while providing comments on the utility and timeliness of the warnings that were given. Later, subjects will convene in focus-group

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settings to explore recollections and opinions of the RDCW function, by means of a facilitated conversation.

The entire compiled database of on-board measurements and subjective opinions of the subjects will be analyzed in many different ways to address the investigative goals of the study.

The field test operations are scheduled to run through next February and the final report will be submitted to the sponsor approximately four months after the conclusion of the field test. RR

UMTRI Publication Awards

The 2004 UMTRI best publication award was presented on May 21 to Jean Shope, Trivellore Raghunathan, and Sujata Patil for their article, "Examining Trajectories of Adolescent Risk Factors as Predictors of Subsequent High-Risk Driving Behavior," which appeared in the *Journal of Adolescent Health.* Shope is the head of UMTRI's Social and Behavioral Analysis Division, Raghunathan is a professor in UM's School of Public Health and a research professor at the UM Institute for Survey Research, and Patil was a research assistant in UM's School of Public Health, who recently graduated.

Two UMTRI research excellence awards were also presented to:

- David Eby, Lisa Molnar, Jean Shope, Jonathon Vivoda, and Tiffani Fordyce,

Awardees include (l–r): David Eby, Jonathon Vivoda, Sujata Patil, Jean Shope, Lisa Molnar, and Michael Sivak.

for "Improving Older Driver Knowledge and Self-Awareness through Self-Assessment: The Driving Decisions Workbook," which was published in the *Journal of Safety*

Research. All authors are from UMTRI's Social and Behavioral Analysis Division.

- Michael Sivak for "How Common Sense Fails Us on the Road: Contribution of Bounded Rationality to the Annual World-wide Toll of One Million Traffic Fatalities," which was printed in *Transportation Research.* Sivak is the head of UMTRI's Human Factors Division.

Modeling Risky Driving Behavior

Risky driving behavior (actions that increase the objective likelihood of a crash or the severity of injury in a crash) causes or contributes to at least 40 percent of crashes. Risky driving, which includes speeding, following too closely, and not using safety belts, is more common among males, young people, and those who score high on tests of sensation seeking. Countermeasures designed to reduce the incidence of risky driving generally have not been effective, primarily because of a lack of understanding of the antecedents of these behaviors or a unifying theory to explain and predict risky driving behavior.

UMTRI researchers have recently launched a study to better understand risky driving behavior and to serve as the basis for creating predictive models. David Eby, research associate professor in UMTRI's Social and Behavioral Analysis (SBA) Division, serves as principal investigator of the study. Lidia Kostyniuk, research scientist in SBA, and James Sayer,

UMTRI / SHEKINAH ERRINGTON

assistant research scientist in UMTRI's Human Factors Division, serve as coprincipal investigators. Scott Bogard, senior engineer in research in UMTRI's Engineering Research Division, is also working on the study.

The theoretical background for the study is provided by a decision-making model of risky driving behavior that was developed for NHTSA by Eby and Lisa Molnar, senior research associate in SBA. The model conceptualizes risky and safe driving behavior as the outcome of a decision-making process. In general, the decision to engage in risky driving is influenced by an individual's risk perceptions; that is, the perception of the likelihood and severity of a crash and the perception of the likelihood and penalty of being pulled over and cited by law enforcement. Several other factors (called considerations in the model) are also involved in the decision to engage in risky driving.

This project "piggybacks" onto UMTRI's road-departure, crash-warning (RDCW) field operational test (see story on page 1). Along with factors specific to the RDCW study, additional vehicle and driver data is being collected for use in this study. Researchers will combine, distill, and analyze that data to derive the following measures of risky driving: following too closely (tailgating), speeding, not wearing safety belts, and using a cell phone.

This study examines a group of subjects for whom detailed, objective measures of risky

driving behavior can be obtained during naturalistic driving, and compares the frequency of these behaviors to scores on a variety of personality measures. Before the subjects started driving the instrumented vehicles, they completed assessments in the areas of sensation seeking, perceptions of risk, locus of control, and a measure of cooperation and competition.

No past work has successfully collected objective measures of risky driving in a natural setting where it is most likely to occur. Instead, researchers have relied on indirect measures of risky driving behaviors such as crash history, citation history, or self-reports from drivers. This project utilizes vehicles instrumented with an array of sensor, communication, and global-positioning-system (GPS) technology to gather information on vehicle speed, position, headway, use of safety belts, time of day, and day of week. Matching this information to geographic information system (GIS) databases allows deriving, for each road segment traveled, the number of lanes, speed limit, land use, and a variety of other potentially important factors.

A large body of work has documented the fact that "sensation seekers" have a psychological need for a higher level of arousal than others, leading to negative traffic-safety consequences. They engage in new, complicated, or emotionally intense activities, such as taking risks, because of the resulting increased arousal. Thus, a sensation seeker might engage in risky driving behavior simply for elevated physiological arousal. Sensation seeking can be measured with a sensation seeking scale (SSS) test, in which behaviors related to sensation seeking are self-reported. SSS scores correlate significantly with frequency of motor-vehicle crashes, traffic citations, and many self-reported risky driving behaviors such as drinking and driving, speeding, and lack of safety belt use. Thus, researchers predict that there will be a significant positive correlation between SSS scores and the frequency of risky driving behavior measured objectively in this study.
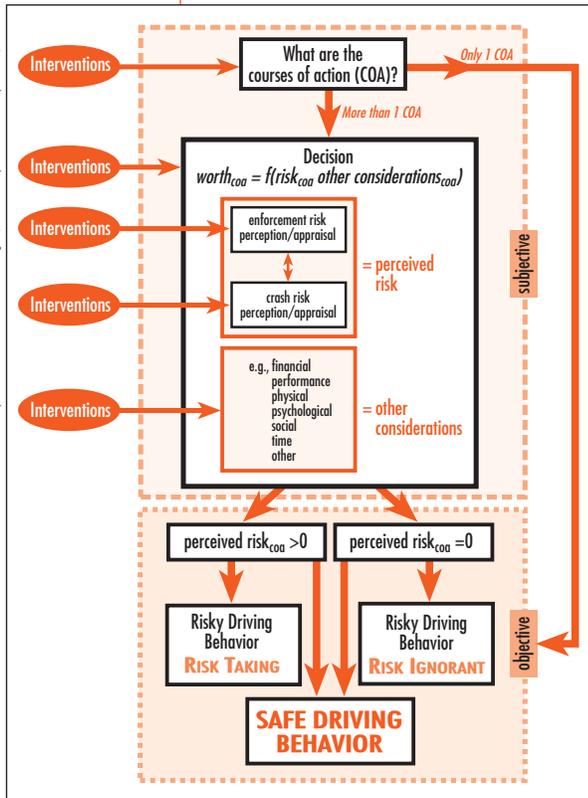
This decision-making model of risky driving behavior was developed for NHTSA by UMTRI researchers David Eby and Lisa Molnar. The model conceptualizes risky and safe driving behavior as the outcome of a decision-making process. In general, the decision to engage in risky driving is influenced by an individual's perception of risk.
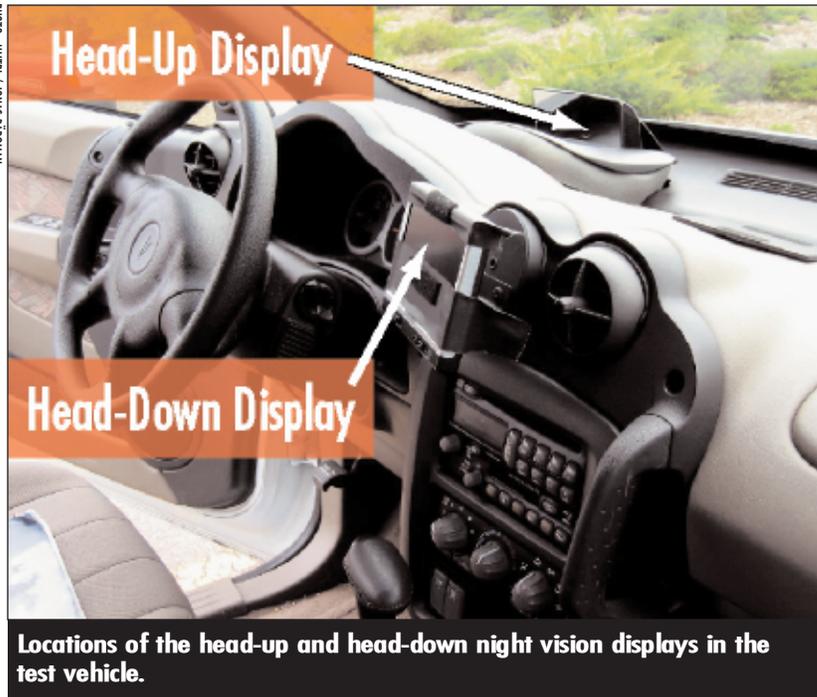
The perception of both crash and enforcement risk is a critical component of risky driving behavior. Researchers are developing and pilot-testing a questionnaire specific to the targeted risky behaviors, based on similar questionnaires used in previous research on driving-risk perception. Researchers predict that those who perceive lower crash and enforcement risk will be more likely to engage in risky driving behaviors.

Another assessment area is the "locus of control," which can be either internal or external. Internal control refers to the perception of an event's outcome as contingent upon one's own behavior, whereas external control refers to perception of an event's outcome as beyond the individual's control. According to the model, risky driving behaviors are selected over safer alternative behaviors because the outcome affords the person greater benefit. People with an external locus of control are likely to weigh outcome benefits of certain driving decisions differently and, therefore, be more likely to engage in risky driving behavior. Locus of control is measured using a short questionnaire. This measure has been utilized in decades of psychological research, although never within this context.

Finally, the study examines cooperation and competition by developing a variant of the prisoner's dilemma game, which uses driving behaviors as the example. The researcher's version of this dilemma is based on time costs and savings and safety of various risky and safe driving decisions. Since safe driving is a cooperative process and many risky driving behaviors come at the expense of reduced safety to others on the road, researchers predict that subjects who select a competitive response on this measure will also engage in more frequent risky driving behaviors.

Field test data collection begins this summer and the project runs through next spring. The project is sponsored by the UMTRI Science of Driving Initiative.

Locations of the head-up and head-down night vision displays in the test vehicle.

PHOTO: UMTRI / JONAS BÄRGMAN

Driving Using a Night Vision System

Night vision systems have the potential to improve the visibility of critical objects at night well beyond the levels that can be achieved with low-beam headlamps. This could be especially valuable to older drivers who have difficulty seeing at night and who are especially sensitive to glare. However, it is unclear whether the benefits of night vision systems are outweighed by ancillary costs, such as added workload to monitor and interpret the forward view depicted by the night vision system.

Researchers in UMTRI's Human Factors Division recently examined this issue by studying driver performance and workload using a night vision system. John Sullivan, assistant research scientist; Jonas Bärgman, visiting research engineer from Autoliv in Sweden; Go Adachi, visiting research engineer from Stanley Electric in Japan; and Brandon Schoettle, research associate engineer, observed young and old subjects driving at night on a test track. They measured the distance and accuracy of target detection, subjective work

In the prisoner's dilemma game, two people are arrested for a serious crime and each prisoner can choose whether to testify against the other. If both refuse to testify, each is convicted of a minor crime and serve only one year in jail. If both testify, both are convicted of a serious crime and both will spend 10 years in jail. However, if only one testifies, the testifier is set free and the other receives 10 years in jail. The cooperative choice is not to testify (whereby both receive a relatively light sentence) and the competitive choice is to testify (with a chance of being set free at the other's expense).

load, and drivers' longitudinal and lateral control of a vehicle in several driving conditions, both with and without a night vision system. Two variations of a night vision system were examined: One included a head-up display of the roadway, mounted above the dashboard, and the other used a head-down display mounted down and near the vehicle midline.

Assisted by each type of night vision system, as well as unassisted, participants were asked to report whenever they observed any of three possible targets (a deer decoy, a small animal decoy, and a pedestrian) positioned along the roadside. In addition, they also performed the same drive unassisted by the night vision system and unburdened by the detection task. Thus, the effect of the detection task on performance could be assessed apart from the introduction of the night vision system.

The primary research question that this study addressed was whether use of a night vision system added to a driver's normal workload. Workload was assessed indirectly using two driving performance measures: average speed and the relative amount of high-frequency spectral energy in steering. Subjective workload was also assessed with the NASA Task Load Index (TLX) questionnaire. Detection performance (detection distance and error) was also recorded. Age- and gender-related performance differences, detectability of different target sizes, and use of different infrared display configurations were also examined.

Above: **An early version of the small animal model was hand-drawn to look like a raccoon. However, as the study took place at night, a highly detailed target was not necessary.**

Results

Overall, night vision systems increased target detection distances for both young and old drivers, with noticeably more benefit for younger drivers. Workload measures did not differ between the unassisted visual detection task and the detection tasks assisted by night vision systems, suggesting that the added workload imposed by a night vision system is small. Additional results of the study are discussed below.

Detection Accuracy. A logistic regression was used to assess the probability of detection as a function of each category of independent variable. A significant effect of age was found. For example, using the fitted equation, an older male driver's odds of detecting a pedestrian while driving with the head-down display was about seven times that of not detecting a pedestrian, while a young male driver's odds were 55 times that of not detecting a pedestrian. An effect of target type was also found, suggesting that the small animal targets were more difficult to detect than the pedestrian or deer targets.

Detection Distance. In general, younger drivers detected objects at farther distances than did older drivers; all drivers detected the large targets (pedestrian and deer) at longer distances than the small targets; and all drivers had longer detection distances with the night vision systems than without them. An interaction was also found between driver age and display condition such that the older drivers' detection distance did not increase as much as that of younger drivers when using the night vision systems. Notably, a significant interaction was not found between target type and display condition, although it seems plausible that the larger targets would show the greatest improvement in detection distance. The average benefit appears greatest for the head-down display condition, particularly with pedestrian targets, although pairwise comparisons between the head-up and head-down display conditions did not indicate a significant advantage of one over the other.

Subjective Workload. Subjects experienced greater workload when trying to detect and report the target objects than they did during baseline driving. However, there was no workload difference in detecting objects visually, with a head-up display, or with a head-down display. The subjective workload of old and young drivers appeared to be most affected by the addition of a detection task. No age difference was found in subjective experiences of workload.

Average Speed. Average speed when not performing any detection tasks was 1 to 2 mph faster than while performing detection tasks, whether visually, with a head-up display, or with a head-down display. When not using the night vision systems, the average speed among male

drivers was slower than that of female drivers, whether or not the detection task was performed. However, the average speed of male drivers was faster when using the night vision systems, whether with a head-up or head-down display.

Steering Ratio. No main effects or interactions among the factors were found on the observed steering ratios.

Discussion

Night vision systems increased detection distances for both young and old drivers, as indicated by the main effect of drive condition (visual, head-up display, or head-down display) on detection distance. This result differs from the findings of others in which the observed benefits seemed to be restricted to younger drivers, under conditions of glare, and for pedestrian targets. However, the interaction in the results between drive condition and age suggests that older drivers experience less benefit. There also appears to be a trend in the results toward greater improvement in detection distance for pedestrians. This, in part, stems from a relatively poor detection distance observed in the unassisted visual detection condition. The researchers suspect that this is due to the comparatively small amount of a pedestrian's body (lower legs and feet) that is below the upper limit of light from a low-beam headlamp. In comparison, the deer targets were wide and short (about 80 cm wide and 100 cm tall) and therefore may have been more effectively illuminated in low-beam lighting conditions. For viewing with night vision systems, where the greater height of the pedestrians does not matter, both pedestrians and deer are highly visible. Perhaps this accounts for the apparently greater improvement in pedestrian detection distance when using a night vision system over unassisted detection.

Overall, the detection results are also consistent with prior research indicating an age-related decline in contrast sensitivity and acuity in dark-ness. This diminished visual capability among older drivers is probably responsible for the missed target detections and the shorter detection distances observed here. The results also suggest that, while the night vision systems improved detection distance, they did not substantially improve the likelihood of target detection. Among younger drivers, the overall percent detection of targets was high (96 percent) whereas among the older drivers, overall percent detection was lower than for younger drivers (78 percent). For both younger and older drivers, there appeared to be little, if any, effect of the night vision system on detection errors. In evaluating the detection results, detection failures do not necessarily mean that drivers were oblivious to the presence of the targets. In addition to cases in which the drivers may have missed the target completely, detection failures included reports made at zero distance from the targets and reports made after targets were passed. RR

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Jonas Bärgman poses with the deer target and the final version of the small animal target, which consists of a gray plastic container filled with warm water, enclosed in a three-sided black box. This view shows the box and its concealing shroud.

UMTRI / JONAS BÄRGMAN

To be recognizable with the night vision system, the deer-shaped detection target was heated by a propane-fueled tent heater. Its visual/thermal blind is partially shown at the bottom left of the photo.

UMTRI BRIEFS

Hot Off The Press

Technical Reports

Blower, D.; Campbell, K.L. 2002. *The large truck crash causation study.* Michigan University, Ann Arbor, Transportation Research Institute, Center for National Truck Statistics. 23 p. Sponsor: Federal Motor Carrier Safety Administration, Washington, D.C. Report No. UMTRI-2002-31.

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www.asphalt.org/GRAPHICS/
ISAPcall4papers01.pdf

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www.mobilitet.2004.dk

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www.ieeeiv.org

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www.carsp.ca/cmrsc.htm

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