UMTRI

RESEARCH REVIEW

• UNIVERSITY OF MICHIGAN TRANSPORTATION RESEARCH INSTITUTE • JANUARY–MARCH 2002 • VOLUME 33, NUMBER 1 •

Inside:

ROAD ROUGHNESS

Research Paves the Way

on page 1

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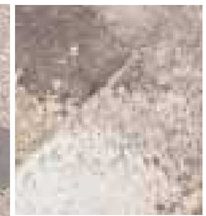
Marine Systems Division

We regret to announce that UMTRI's Marine Systems Division closed on May 1, 2002. The Division was formed in the early 1980s by Howard Bunch to conduct research in ship production and marine transportation. Over the years the Division grew, although funding was often difficult to obtain.

At various times in recent years, the group considered moving to the University of Michigan's Naval Architecture and Marine Engineering (NAME) Department. With the recent loss of the NSNET site and the National Shipbuilding Research and Documentation Center contract, a baseline of support was eliminated. Tom Lamb and Mark Spicknall have moved their research to NAME. RR

THE SHAPE OF ROADS TO COME

MEASURING AND INTERPRETING ROAD ROUGHNESS PROFILES



PHOTOS: UMTRI / SHEKINAH ERRINGTON

Thanks to improvements in methods for measuring road roughness, bumpy roads may one day become rare. Road profiling technology allows engineers to assess the roughness of in-place concrete and asphalt pavements, as well as set benchmarks for newly laid pavement. Roughness is one of the best indicators of the "health" of a road surface, and certainly one most evident to the public.

UMTRI's involvement in the field began in 1979 when the National Cooperative Highway Research Program (NCHRP) commissioned Drs. Tom Gillespie and Mike Sayers, research scientists in UMTRI's Engineering Research Division, to develop better ways to calibrate the systems then used by state highway departments to measure roughness. Following that, the World Bank called upon them to address the same problem for highway engineers throughout the world. The result of their research is the International Roughness Index (IRI), a standard scale used throughout the world to quantify the roughness of roads. The IRI summarizes the roughness qualities that impact vehicle response (such as vehicle vibration), and is most appropriate when a measure is desired that relates to overall vehicle ride, operating cost, dynamic wheel loads, and overall surface condition.

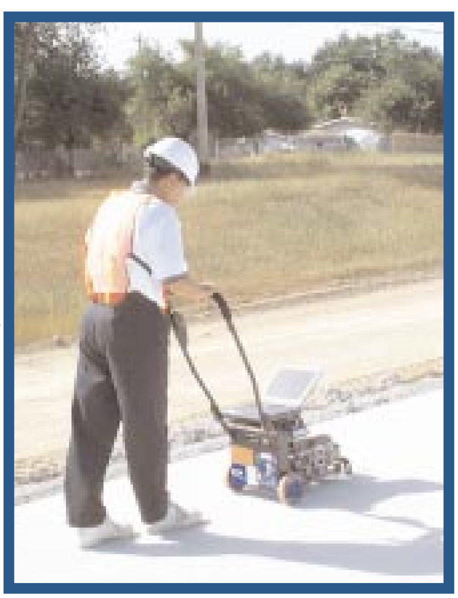
The IRI was developed to correlate with the output of response-type road roughness measuring systems, such as the Mays and PCA meters, which had been in use for 50 years to monitor pavement roughness. The IRI is determined by measuring the profile along the wheel paths of the road, and then filtering the profiles through a quarter-car mathematical model to simulate the suspension deflection of a passenger car. The NCHRP research led to a specific set of parameters for a quarter-car computerized response system, called the golden car. Several years of the NCHRP research were spent developing a profile index, building on the 50 years of experience accumulated by highway departments using in/mi indices (inches of suspension stroke per mile of travel). Development and testing for the IRI was continued in the 1980s by the World Bank, to provide a measure of quality control on road systems being built with Bank loans in less-developed

continued...

countries. For this purpose the Bank sponsored an International Road Roughness Experiment in Brazil. The experiment was designed and conducted by Gillespie and Sayers to verify that roughness measuring equipment used throughout the world could be adapted to measurement of the IRI.

The IRI is now widely used by state and federal agencies, and by independent organizations concerned about road roughness. The Federal Highway Administration (FHWA) uses it to rate road performance, assess changes in the overall condition of the nation's highways, and predict future highway investment needs. States use the index as an indicator of pavement performance state or district wide, and as a construction specification when laying new pavement. Non-governmental analysts use the IRI data to rate performance and occasionally publish "report cards" comparing pavement conditions state by state.

The data from which the IRI is derived is collected with a profiler. High-speed road profiling began in the 1960s with Elson Spangler and William Kelly's invention of the inertial profilometer at the General Motors Research Laboratory. Modern profilers are simply vehicles instrumented with accelerometers and road surface sensors that can track the vertical deviations in the surface shape while traveling at normal highway speed. Variations are also built on light-weight vehicles like golf carts so they can make measurements on freshly laid surfaces.



PHOTOS—ABOVE, RIGHT & FAR UPPER RIGHT: UMTRI / STEVEN M. KARAMIHAS

COURTESY OF AJAX CONSTRUCTION

above: **Computerized profilograph, the traditional tool of choice for measuring new pavement roughness.**

left: **Gamaco slipform paver, laying new concrete.**

top: **Digital level used for profiler verification.**

directly above: **Walking profiler taking a reference measurement.**

STANDARDIZING RESULTS

Although there has been great improvement in profiling technology over the past few decades, differences in equipment still exist, i.e., laser, infrared, ultrasonic, and optical road sensors are used. A U.S. General Accounting Office report[1] states that these sources of variability limit the comparability of data from state to state. Furthermore, concrete and asphalt pavements may differ in texture, which would cause states with more concrete pavements to have higher index readings. Another disparity is whether the profiler takes measurements over the path of the right wheel, the left wheel, or both wheels (averaging the results).

Steve Karamihas, a research associate in UMTRI's Engineering Research Division, points out that in the early days of profiling, "Any incompatibility in measurement methods would prevent two different agencies from reliably comparing roughness data, and data could not be compared between different profilers in the same agency. In an attempt to make data comparable from one system to the next, the NCHRP conducted correlation experiments among various profilers. Calibration by correlation lets you take data from diverse profilers and correlate it back to the standard, but with an accuracy of about plus or minus 20 percent. So UMTRI was asked to come up with a better standard to calibrate against."

The challenge in making profilers comparable was to first ensure that they worked correctly. Profilers were very expensive, and in the late 1980s many state DOTs built their own to reduce costs. As a result, Karamihas says, technical differences resulted, causing a need for standardization. Karamihas explains, "When data are collected with similar instruments and run through a standard analysis program, you get consistent results." By the mid 1990s, the focus shifted to establishing and encouraging adoption of best practices for profiler design and use.

Karamihas says a critical problem that road profiler users face is a lack of knowledge about the technology. Most research in the field has been completed and the newest frontier is teaching people what is already known. "The technology for profilers is out there, but we haven't quite overcome the fact that they are not all working properly," Karamihas says. Accordingly, Sayers and Karamihas developed a two-and-a-half day course of profile measurement and analysis, along with a companion document, *The Little Book of Profiling* (available online at **http://www.umtri.umich.edu/erd/roughness/lit_book.pdf**). The course introduces new users to the fundamentals of how profilers work and how to properly utilize the data.

Sayers and Karamihas also developed a user-friendly profile-analysis software package, RoadRuf, which includes many profile analysis tools. The software is provided to participating states and is available online at **http://www.umtri.umich.edu/erd/roughness/rr.html**. Since it has been posted, about 100 people from 20 countries have contacted Karamihas about obtaining the software.

PROFILERS ARE USED FOR FOUR MAIN PURPOSES:

- ***Monitoring the condition of a road network for pavement management systems***
- ***Evaluating the quality of newly constructed or repaired sections***
- ***Diagnosing the condition of specific sites and determine appropriate remedies***
- ***Studying the conditions of specific sites for research***

COMPUTING THE INDICES

A profile index is a summary number calculated from the many numbers that make up a profile. Details of the calculation determine the significance and meaning of the index. The number might be related to the motion of a mathematical vehicle model (e.g., the IRI), or to other indices used in the past. More recent analysis methods have been developed to quantify curling of concrete slabs and to identify locations where surface grinding can be used to produce smoother pavements. A true profile index should be portable (meaning it can be measured by different types of profilers), reproducible, and stable over time. Many roughness indices can be created from a single profile.

continued...

[1] *Transportation Infrastructure: Better Data Needed to Rate the Nation's Highway Conditions*, United States General Accounting Office Report to Congressional Committees, GAO-RCED-99-264, September 1999.

All roughness indices are calculated, using mathematical transforms, in four basic steps:

1. *Determining the number of profiles to input.* Most indices are calculated from a single profile, but some indices require two-one for each wheel track.
2. *Filtering out wavelengths and data that are not of interest.* Some analyses require several filters used in sequence.
3. *Accumulating and reducing the filtered profile.* The sequence of transformed numbers must be reduced to a single index value. This is often done by accumulating either the absolute or squared values of all the numbers into one cumulative value.
4. *Scaling the summary number.* The final step is converting the accumulated number to an appropriate scale. This generally involves dividing by the number of profile points or the length of the profile to normalize the roughness by the length covered.

After the profile has been measured, it is run through a computer program that calculates the roughness index. Statistics from two or more valid profilers are directly comparable, without the need for any conversions. Valid profilers also produce statistics that are stable over time, or repeatable. Through the Road Profiler User Group and FHWA's Highway Performance Monitoring System, profiler users have shared insights and experiences to improve procedures in measuring IRI. Today, IRI measures from different states, and even different countries, are largely compatible data that can be compared reliably.

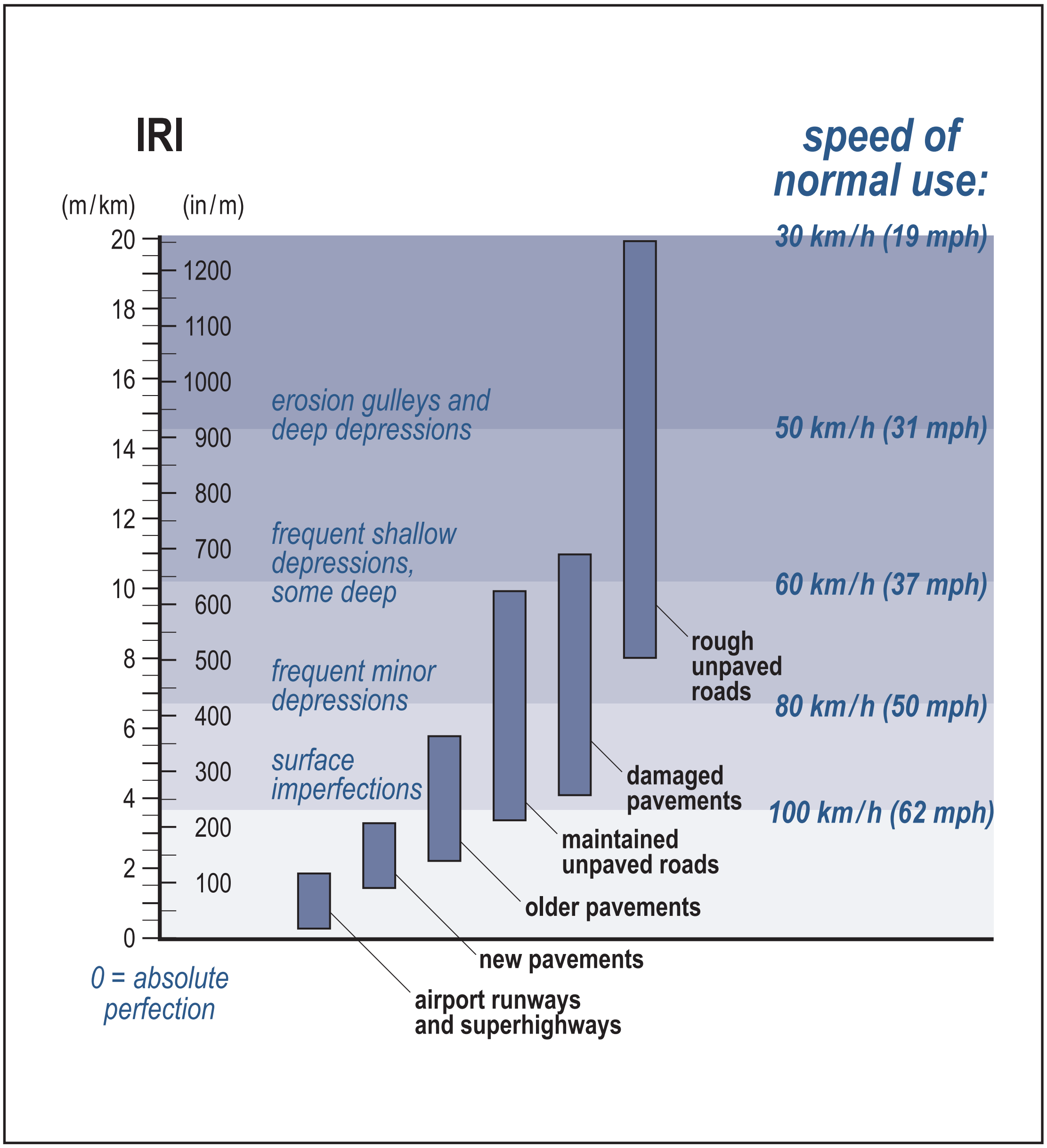


Figure 1. **The International Roughness Index (IRI) is a standard scale used worldwide to quantify road roughness. IRI ranges represented by different classes of roads are shown above.**

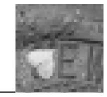
USING ROAD PROFILE DATA FOR IMPROVED RIDE

Aside from improving the nation's roadways, road profiles are also useful in further road research and vehicle design. Data on road input are used by UMTRI researchers who study vehicle dynamics. Measurement and interpretation of road roughness can help researchers predict truck dynamic loading. "Our focus is on vehicle dynamics, predicting what vehicles do in response to road roughness in terms of vibration, cargo acceleration, and human comfort," Karamihas remarks. "One of our biggest studies involved how roads responded to trucks of different configurations." In that study, Gillespie and Karamihas modeled truck-road interaction to find how trucks' suspensions, axle loads, axle spacings, vehicle gross weight, and load sharing among axles affected road wear and damage.

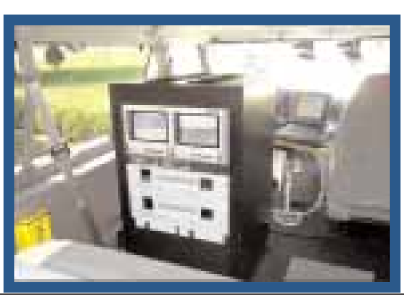
From a design perspective, Vasanth Krishnaswani, an assistant research scientist at UMTRI and an adjunct professor in Mechanical Engineering, incorporates road data into modeling vehicle seats that reduce road vibration. UMTRI researchers also work with General Motors and other vehicle manufacturers to improve a car's feel on the road. Vehicle engineers are interested in representative road data to help them design cars that ride well with minimum vibration and road noise. GM uses simulation software that allows making design changes, based on road performance, early in the life of the car. UMTRI is also working with GM to design a new proving ground site that is representative of a wide variety of the roughness features that are found in public roads.

Karamihas is also working with Mike Swan of Dick Corporation (the construction manager for the Ohio Turnpike Third Lane Project), on a section of the turnpike to find and get rid of bumps. They use the IRI to work out which bumps to fix and to identify those that have no direct relevance to ride. Then using a patented method, they simulate the effects of diamond grinding in a rough area to determine the degree of improvement expected. After grinding, a profiler is rerun over the smoothed area to confirm the correction.

Later this year, Karamihas plans to investigate whether there are individual hot spots that govern how drivers judge the overall feel of the car on the road. He also plans to update *The Little Book of Profiling*. **RR**



For a related story, see "Trucks and Pavement Wear: Findings from New Research" in the May–June 1994 issue of ***UMTRI Research Review.***



PHOTOS: UMTRI / STEVEN M. KARAMIHAS

top: **High-speed profiler, Z.F. Industries.**

above right: **High-speed profiler sensor bar.**

above left: **Lightweight profiler used for assessment of new construction roughness, Dynatest/KJL6400.**

left: **High-speed profiler with on-board data acquisition and processing hardware.**

UMTRI Wins Two Major FHWA Contracts

UMTRI recently won two Federal Highway Administration (FHWA) contracts to improve telematics safety and to prevent road-departure crashes. University-wide, these contracts are ranked among the five highest received in the 2002 fiscal year. Receiving contracts of this size "reaffirms UMTRI's position as the premier place to do driving research," says UMTRI director Barry Kantowitz.

Technical Support & Assistance for the FHWA's Human-Centered Systems Team

How should cell phones, navigation systems, and other telematics devices be designed to make driving more convenient without making it more dangerous? How do you get motorists to slow down in constructions zones? Under a $16 million FHWA contract, UMTRI will oversee and conduct research aimed at answering these and other questions.

"The purpose of this research is to save lives," says UMTRI director Barry Kantowitz. "Forty-one thousand people die on American highways each year. By improving highway safety and design, we can substantially lower that number." In the process, UMTRI and its collaborators also will make significant theoretical and methodological contributions to the "science of driving," he adds.

The contract from the FHWA's Turner-Fairbank Highway Research Center will focus on two main areas: highway geometry issues—such as how to design bridge approaches and construction zones to get drivers to slow down to safe speeds—and human factors research related to telematics devices. Human factors research examines driver capabilities and limitations in order to make the driving task safer, easier, and more efficient.

"We're especially concerned about the introduction of telematics devices without sufficient safety research," says Kantowitz, who has studied driver distraction for 15 years. "In order for the potential benefits to be achieved, we must observe driving behavior on the highway and in driving simulators so that the technology ultimately helps the driver, rather than making driving more difficult." The research will make use of a new driving simulator that UMTRI expects to have in place later this year (watch future issues of UMTRI Research Review for simulator details).

Finding ways to integrate various in-vehicle communication and information devices is also an important area of research, adds Kantowitz, who is program manager for the contract. "There are so many things that can distract drivers inside a vehicle. How do you make them all work together in a safe, harmonious way?"

UMTRI's university partners on the contract are the University of Iowa's department of industrial engineering, Georgia Tech Research Institute, and Virginia Tech Transportation Institute.

Intelligent Vehicle Initiative Road-Departure Crash-Warning Field-Operational Test

With a $10 million contract from the FHWA and $6 million in matching funds from UMTRI's industrial partners, Visteon Corp. and AssistWare Technology Inc., a research team will develop and test a new crash-avoidance system in a fleet of eleven passenger cars. UMTRI will serve as the prime contractor, coordinating the work of the partnership and conducting the field experiment.

The system is designed to prevent road-departure or run-off-road crashes, which account for 41 percent of all in-vehicle fatalities in the United States (some 15,000 per year). Crashes of this type occur for a variety of reasons, from excessive speed to driver inattention or incapacitation (due to drowsiness or intoxication).

UMTRI and its partners plan to develop a dual-mode, road-departure-crash-warning (RDCW) system, which will alert the driver when the vehicle begins to wander off the road or when the vehicle is traveling too fast for an upcoming curve. The system, which will use information gathered by inertial, video, and radar sensors, plus a global-positioning-system module, could prevent or lessen the impact of some road-departure crashes.

"This research builds upon UMTRI's growing strength in naturalistic measurement of the driving process," says Robert D. Ervin, head of UMTRI's Engineering Research Division and project director on the study. "We hope to observe the way lay persons interact with this novel warning system when they operate one of the instrumented test vehicles for several weeks as their personal car."

Investigating Real-World Crashes

An Interview with UMTRI's Crash Investigation Coordinator, Joel MacWilliams

Each year in the United States, about 45,000 people are killed, and hundreds of thousands sustain disabling injuries in car crashes. In-depth investigations of real-world crashes can provide valuable information on the performance and effectiveness of new restraint and vehicle crashworthiness technologies, and on the validity of government regulations and consumer safety ratings. The UMTRI Crash Investigation Team has been conducting in-depth investigations for more than 34 years under the sponsorship of the automotive industry. The program functions within UMTRI's Biosciences Division and is directed by Dr. Larry Schneider, a senior research scientist and head of UMTRI's Biosciences Division.

Joel MacWilliams is the coordinator of UMTRI's field investigation team, which also includes Jamie Moore and Tim Compton, and has been conducting investigations of motor vehicle crashes for more than 23 years. Having started his career as a crash investigator at UMTRI in 1980, he soon accepted a position as a contractor for NHTSA's National

> **"I love the job; it's like doing crossword puzzles. They all require the same process, *but each one has a different solution.*"**

Joel MacWilliams takes measurements of a frontal collision.

Left: **A real-world side impact that typically causes moderate to severe injuries for the near-side occupants.**

Right: **A frontal tree impact that is a common single-vehicle crash throughout the United States.**

PHOTOS: UMTRI / JOEL MacWILLIAMS

Automotive Sampling System (NASS), where he was employed for more than 15 years investigating crashes throughout the United States. In 1995, Joel returned to join UMTRI's crash-investigation program, where he currently manages the day-to-day operations of selecting and investigating crashes in the southeast Michigan area. Joel says, "Our focus at UMTRI is on understanding the causes of different types of injuries in different types of crashes for vehicles equipped with the latest safety technology, and thereby on evaluating the effectiveness of the latest safety devices, such as depowered and advanced airbags, seatbelt pretensioners, integrated seat belt systems, and side-impact airbags and side curtains."

Each year, UMTRI's crash investigation team reviews about 6,000 police accident reports of crashes occurring in several southeast Michigan counties. Based on selection criteria and current topics of interest to the industry and safety community, UMTRI selects 100 to 150 of these crashes for in-depth investigations. The team regularly sorts through police reports to look for moderate to severe crashes that are survivable. MacWilliams says, "This type of scenario provides the best data for furthering our understanding of injury causation and improving occupant protection. Spectacular crashes that can't be survived because the damage to the occupant space is catastrophic don't provide very useful clues as to how safety systems can be improved." In addition to police reports, UMTRI investigators occasionally get calls from sheriff's departments or hospitals, locally and from around the country, about cases that they find puzzling. If the case meets their crash criteria, UMTRI investigators travel to perform detailed inspections and measurements of the involved vehicles and crash site. Each crash investigation also involves documenting occupant injuries from medical records and/or from autopsy reports, interviewing the occupant(s), police, and witnesses to

Technology in Crash Investigation

The event data recorder (EDR) is a new technology that provides quantitative information about a crash that can be useful to crash investigators. Its primary function is to decide whether to deploy the airbags, but it also provides data on the speed of the vehicle before impact, the change in speed during impact (delta-v), the ignition cycle when the airbag deployed, whether the driver and passenger seat belts were being used, whether warning lights were displayed on the dashboard, and, in pick-up trucks, whether the passenger airbag was turned on or off. Some EDRs also provide information on engine rpm, percent throttle, and brake use/non-use at the time of the crash.

the crash, and obtaining information on belt-restraint usage, and occupant height, weight, gender, age, stature, and body mass.

All information from the investigations is confidential and is protected by the State of Michigan Public Act No. 26 from access through the Freedom of Information Act. MacWilliams says, "When we work with police officers who may also be inspecting a vehicle, our emphasis is on helping them to 'read' accident scenes, not on providing them with our opinions on the crash. We work with them on general skills, such as how to tell if someone was wearing a seatbelt and how to tell if a specific injury was caused by airbag energy or by the crash forces." UMTRI investigators also assist police officers by providing them with computer programs that supply vehicle specifications that are needed for accurate crash reconstructions.

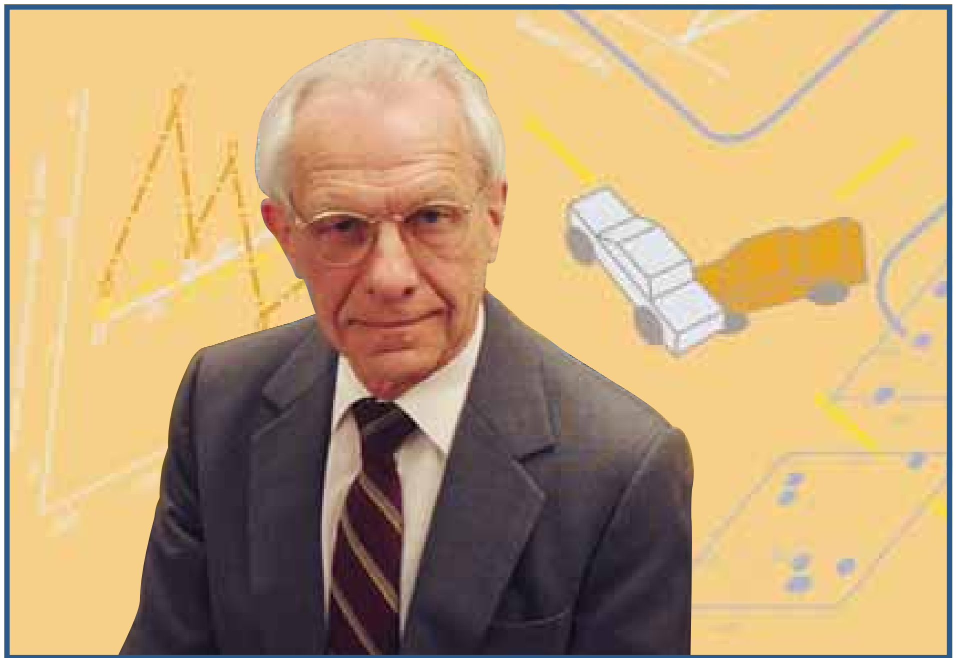
MacWilliams says, "You rarely learn anything specific about injury causation from one crash, but after looking at many crashes of the same type, you begin to see patterns between injuries and crash factors. We collect thousands of pieces of data for every crash, but it is usually only one or two pieces of information that is significant in terms of figuring out what caused serious injuries to an occupant. We seek to understand which parameters (crash severity, restraint usage, impact type, age, gender, and pre-existing medical conditions) are most relevant to injury causation. We collect and examine the same data for every crash, but the focus changes with the crash type."

The technology of safety devices in cars has changed since MacWilliams joined the field, evolving from the lap and shoulder belt to airbags and energy-absorbing knee bolsters combined with three-point belts that include belt load limiters and pyrotechnic belt pretensioners. In the past, cars were larger but their structures were not nearly as crashworthy as they are today. Now cars are designed to absorb the crash energy exterior to the occupant compartment, and do a much better job of keeping vehicle interior components from intruding into the occupant space. This allows occupants who are using the latest restraint technologies to "ride down" the vehicle crash pulse over a longer period of time, and thereby reduces the likelihood of injury due to contact with vehicle components. MacWilliams says, "In the last 10 years, what we think of as a survivable frontal crash has changed significantly, due in large part to airbags, improved belt restraints in vehicles, and general improvements in the structural design of vehicles. If a person is wearing the three-point belt, they are very likely to survive even a 45 to 50 mph frontal crash." RR

Watch the ***UMTRI Research Review*** for more in-depth coverage of UMTRI's Crash Investigation Team.

A Career Modeling Fatality Risks

Hans Joksch Examines Fatality Risks in Collisions



UMTRI / SHEKINAH ERRINGTON

Hans Joksch

Hans Joksch has been working on traffic safety problems, mostly for NHTSA, since 1967. He came to UMTRI as a research scientist in the Survey and Analysis Division in 1993. "I was happy to join UMTRI for its scientific reputation and the great support it provided me to engage in research," Joksch says. He retired in early 2002.

Most of Joksch's work involved developing mathematical models for predicting injury and fatality risks in traffic accidents. His most recent work uses innovative analytic approaches to study airbag effectiveness and vehicle compatibility in collisions.

Initially, Joksch dealt with how motor vehicle safety standards affect fatality and injury risk. In the early 1970s, the fuel crisis increased the use of lighter cars. This raised questions about how lighter car weight would affect fatality and injury risks. Most work at that time looked at large and small cars separately; Joksch was one of the few researchers who were concerned with their interaction on the highway. This investigation required considerable research to examine other factors such as travel speed, driver/occupant age, and type of restraint system. Joksch says, "The factors were so closely correlated that they could easily mask real effects or create spurious effects, so complex models were required to isolate the effects." In the 1990s, SUVs, vans, and pickup trucks (known collectively as LTVs) were added to the investigation, because they—SUVs in particular—began replacing cars as personal vehicles.

The Method

In a recent research project, Joksch examined how certain characteristics of cars and LTVs influence the fatality risk for occupants in a collision. He estimated fatality risks, at the make-model level, by combining fatality data from NHTSA's Fatality Analysis Reporting System (FARS) with data on collision involvements from the National Automotive Sampling System's (NASS) General Estimates System (GES). These databases contain very different statistics, and much work is needed to make them compatible. To address vehicle compatibility issues, Joksch added information from the New Car Assessment Program (NCAP) on structural stiffness and vehicle geometry, the two main sources of vehicle incompatibility in collisions.

The factors used in modeling included vehicle impact points, speed limit in the area of the collision, vehicle weights, driver ages and genders, and airbag availability. Joksch then developed various complex statistical models to determine the aggressivity, or incompatibility, between LTVs and cars. He also determined airbag effectiveness as a function of crash, vehicle, and driver characteristics, attempting to identify situations where the effectiveness is unusually high or low. Such situations can provide insights to improve airbag performance.

The Results

Preliminary results showed that in collisions with pickup trucks or vans, car occupants were exposed to a much higher fatality risk than in collisions with other cars. In collisions with SUVs, the risk for car drivers was even higher. The controlled fatality risk for the car driver tended to increase with the weight of the striking vehicle, its height of the center of force, and its frontal static stiffness, as measured in crash tests.

Joksch says, "A car driver's fatality risk in collisions with an SUV was three times as high as in collisions with a car, and in collisions with a van or pickup it was two times as high. In front-end collisions, the corresponding factors were six and four, respectively." After correcting for vehicle weight, light trucks increased the risk to car occupants by 50 to 100 percent. The fatality risk for the occupants of LTVs in collisions with cars is much lower than that of the occupants of the car. However, Joksch says, "That does not mean that LTVs are more crashworthy than cars. The numbers are lower because they increase the risk to car occupants so much. In collisions between light trucks, their occupants face similar risks as car occupants in collisions between cars."

In single vehicle accidents, occupants of LTVs face higher risks than car occupants, because of the higher fatality risk in rollover accidents, which are relatively more frequent in light trucks than in cars. "It is not possible to compare the absolute risks because no good measures of the frequency of situations that precede rollovers exist, and the calculations have to be based on strong assumptions," Joksch explains.

Joksch also found that in collisions between two cars, the fatality risk for drivers in cars with airbags is about 40 percent lower than in non-airbag cars. In single car crashes, excluding rollovers, it is about 30 percent lower. These numbers are higher than previous estimates; future work will have to find the reasons for the difference. There are strong suggestions that overall airbag effectiveness is higher for women than for men, despite crashes where short women, who would have survived without airbags, were killed by them.

The Future

In his retirement, Joksch plans to obtain "the most powerful personal computer" and continue to work on these questions. He says, "I'd like to look at all the fine points and turn all stones over, which you can't always afford to do under specific research contracts." He and his wife will split their time between Ann Arbor and Germany. RR

Hot Off The Press

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Conferences & Events

2002 Future Car Congress
June 3–5, Arlington, Virginia
http://www.futurecarcongress.org/

Retroreflective Materials Used in Transportation
June 12–13, Tysons Corner, Virginia
http://208.233.211.80/TRAIN/retrodates.html

SAE Digital Human Modeling Conference
June 18–20, Munich, Germany
http://www.sae.org/calendar/dhm/index.htm

Managing Fatigue in Transportation
June 25–26, Evanston, Illinois
http://www.nutc.northwestern.edu/fatigue

SAE IBEC Conference
July 9–11, Paris, France
http://www.sae.org/calendar/ibe/index.htm

Injuries, Anatomy, Biomechanics, and Federal Regulation
July 15–17, Chicago, Illinois
http://www.sae.org/calendar/semsafe.htm#injuries

ITE 2002 Annual Meeting
August 4–7, Philadelphia, Pennsylvania
http://www.ite.org/meetcon/2002/AMinfo.htm

16th International Conference on Alcohol, Drugs, and Traffic Safety
August 4–9, Montreal, Canada
http://www.saaq.gouv.qc.ca/t2002/index_a.html

Applications of Advanced Technology in Transportation
August 5–7, Cambridge, Massachusetts
http://www.asce.org/conferences/aatt2002/

Safe and Secure Roadways (NAGHSR Annual Meeting)
September 8–11, St. Louis, Missouri
http://www.statehighwaysafety.org

ITE 2002 International Conference
September 12–13, Melbourne, Australia
http://www.ite.org/

Transportation Association of Canada Annual Conference
September 15–18, Winnipeg, Manitoba
http://www.tac-atc.ca

e-Safety Congress and Exhibition
September 16–18, Lyon, France
http://e-safety.expo24-7.com/ RR

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