

# Exploring Ways to Prevent Injuries During Vehicular Crashes

BY ELIZABETH O. COOPER



**D**ALE EARNHARDT'S DEATH IN A LAST-LAP CRASH DURING THE 2001 DAYTONA 500 DEVASTATED MILLIONS OF RACING FANS, BUT AN OLD DOMINION UNIVERSITY FACULTY MEMBER BELIEVES THE NASCAR DRIVER COULD HAVE SURVIVED THE ACCIDENT HAD HE BEEN WEARING A SPECIALLY DESIGNED HELMET.

“The HANS Device could have prevented Earnhardt’s death,” says Sebastian Bawab, associate professor of mechanical engineering. A helmet connected to a U-shaped tethered shoulder harness, the HANS Device was developed to protect drivers from head and neck injuries by limiting extreme movements of the head. According to Bawab, an increasing number of NASCAR drivers use the device in the wake of Earnhardt’s death from head injuries. However, the helmet has also aroused controversy on the racing circuit.

“People feel like it limits what you see because it prevents head movement from left to right,” he explains. “It’s a foreign environment for the driver, and they have enough stress handling the car. Historically, if you tell a race car driver, ‘We can make you go three miles faster,’ they want to hear that, but if you say you have a design for a safety device, they kick you out. However, this perception has been slowly but surely changing.”

While the HANS Device allows only minimal injury to the neck, Bawab says it does not protect the head from absorbing more force from the impact. “The head and neck are closely coupled with the use of the HANS Device. The neck becomes more stable, but gravitational forces get transferred more so to the head. How much help is the HANS Device? Is it hurting at all?”

## Crashworthy Vehicle Design

Bawab is the first Old Dominion mechanical engineer to pursue a research focus in biomechanics, which integrates the mechanical and biological aspects of living systems. In biomechanics, engineering methods are used to measure and understand how the body moves, how movement is controlled and how forces act on biological tissues during movement. Bawab’s research focuses on crashworthy vehicle design or a vehicle’s capability to prevent injury to the occupants during a collision. In a collision, occupants collide against the vehicle’s interior as they are subjected to forces that can lead to injury. Vehicles that are crashworthy are able to disperse those forces over as large a period of time and distance as possible and direct those forces to parts of the body that are better able to survive them. The best-known crashworthy features include seatbelts and airbags. Bawab, along with several Old Dominion graduate mechanical engineering students, has been using MADYMO (Mathematical Dynamic Model) engineering software of passenger vehicles for simulating side, rear and front impact crashes, rollover analysis and head/neck and knee injuries. He has also used MADYMO software to evaluate the performance of the HANS Device.

“I’ve always been interested in human anatomy,” says Bawab, who has been working with biomechanics since 2000. “I didn’t think about vehicular crashes as much. If you look at cars today versus 20 years ago, although they are typically smaller, they’re better. You’re never going to have a perfect vehicle. Sometimes you make mistakes, but that’s how

you get better. You learn from your mistakes.”

MADYMO uses multibody and finite element techniques involving the interiors and exteriors of vehicles, including steering and airbags, to analyze vehicle safety using a variety of dummy models and restraint systems under various crash scenarios.

“We apply Newton’s Law to rigid bodies and moving parts,” Bawab explains. “Humans are biological machines, an open chain system. This model determines the effects of crashes on humans by allowing you to see the behavior of rigid bodies and finite elements as a function of time. We’re trying to understand human behaviors and performance due to different kinds of impact. The modeling techniques give us much power.”

## Knee Bolsters and Hip Injuries

Bawab and his students are also studying the relationship between knee bolsters and lower extremity injuries. Installed under vehicles’ dashboards and glove compartments for about two decades, knee bolsters are basically plates covered with foam. Although they have reduced knee fractures, the bolsters have also led to an increase in hip fractures or dislocations during a collision. Bawab’s recent research studies the effect of placing an airbag in the knee bolster, asserting that airbags would protect motorists and front-seat passengers by redistributing the forces against their bodies and helping to maintain them in upright positions. An airbag used with knee bolsters would be smaller than a standard-size airbag but would still be large enough to cover the area of impact. Using the MADYMO software to design the airbag and simulate its effect on the hip, femur and knee joint loads during frontal collisions, Bawab has determined that airbags would result in fewer hip injuries.

“If the knee hits the bolster hard enough, you would have a hip fracture because the impact diffuses energy from the knee to the hip. Most cars have padding to protect the knees, but with severe crashes, we see hip fractures,” he explains. “An airbag stops you from sliding and hitting the knee.”

## Brain Injuries from Rear-End Collisions

Bawab and his students are also analyzing the brain’s behavior when it is subjected to force emanating from a rear-end collision. With this study, they are comparing brain injuries from rear-end collisions.

“We study the stress and strain of the brain when the head hits the headrest during rear impact collisions. It’s a force field. The head is seeing some force when energy is transferred to the brain.” Using the brain model, additional studies will be conducted to understand the energy transfer

to the brain during all different sorts of sports impact such as boxing and football.

Head and neck injuries, also known as whiplash, can occur as a result of gravitational forces on the headrest during a collision. “We’re trying to study the effect of the headrest on whiplash in a rear impact to see what type of impact gravity would have,” Bawab explains. “We’re using various types of headrests to see if a person should sit in a normal position or if it is riskier if he’s leaning forward.”

## Making the A-Pillar Safer

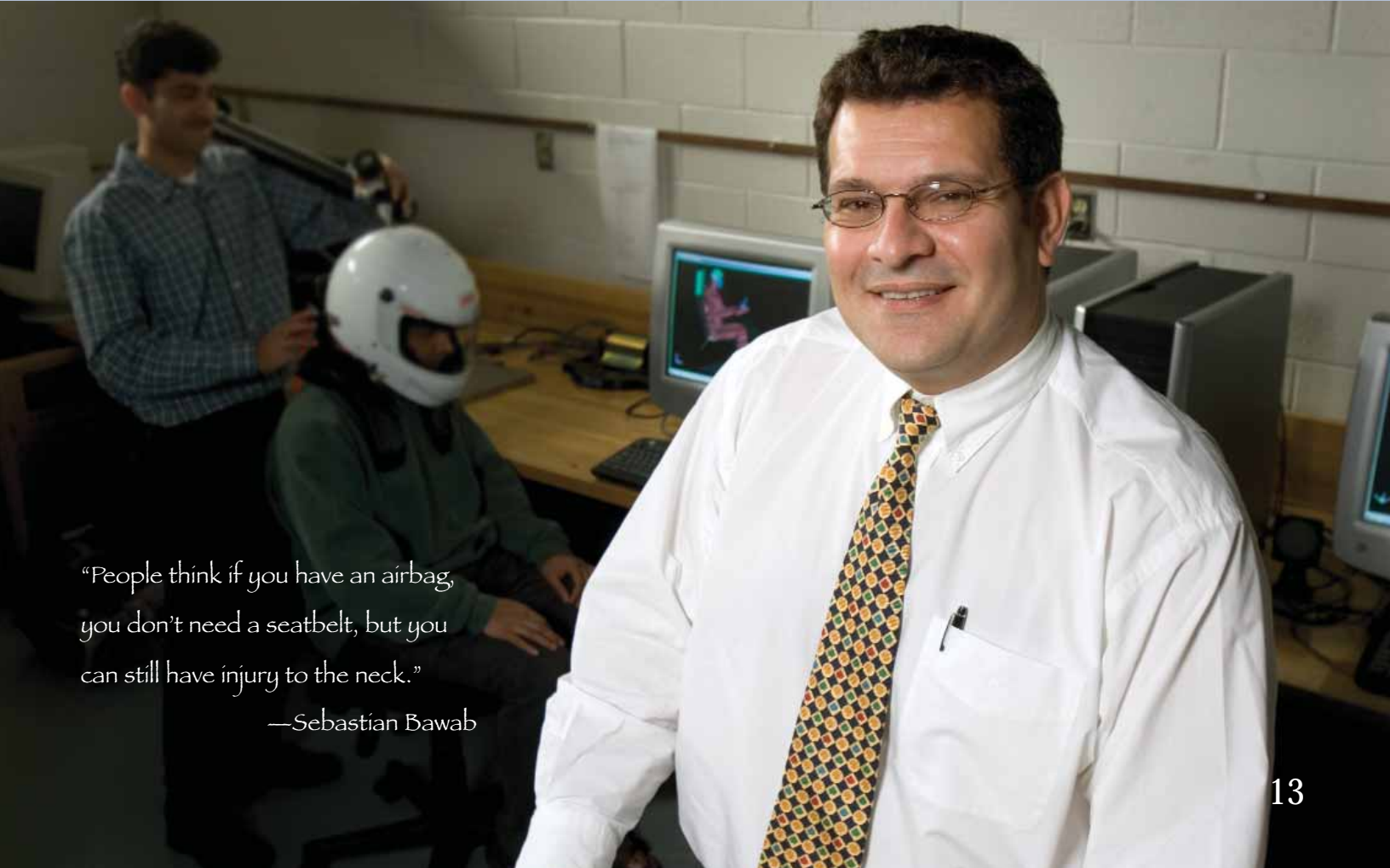
Bawab and colleagues Gene J. Hou, professor of mechanical engineering; Steven A. Hans, a Ph.D. student in mechanical engineering; and Michael L. Woodhouse, a retired Norfolk State University professor, additionally are embarking on a new frontier in crashworthy vehicle design by reconstructing a vehicular roof deformation (crush) using prescribed nodal motion. They prescribe the nodal displacement of the roof being crushed during a rollover to determine how much the roof was deformed, what it looked like before the impact and how the roof deformation took place in a rollover. This is an extremely uncertain phenomenon because the compartment intrusion into the passenger area creates all types of injury that are typically very difficult to

predict. The researchers use a FARO Gold Arm digitizer to scan the actual crushed vehicle and model of it. These two surfaces are meshed and correspondingly mapped. The roof deformation is then prescribed as a function of time where it starts at the non-deformed roof and ends at the deformed one.

“We want to see how the collapse of the roof affects the motion of the occupants and the types of injury that can typically occur,” Bawab says. “In the case of unbelted occupants, we should be able to determine the exit point out of the vehicle compartment.”

He adds that the various elements to make a vehicle more crashworthy must work in tandem to best protect the vehicle’s occupants. “People think if you have an airbag, you don’t need a seatbelt, but you can still have injury to the neck. The lap belt alone is also extremely dangerous, especially for children. They can die of liver laceration.”

Working with crashworthy vehicle design has made Bawab more safety conscious when he gets behind the wheel or even when he’s climbing into one of the passenger seats. “As an adult, I never wore a seatbelt in the back seat because it is not the law,” he says, “but I’ve studied enough simulations that I wear it automatically now.”



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—Sebastian Bawab