High-tech speed bump detects damage to army vehicles

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Douglas Adams, a Purdue associate professor of mechanical engineering, and graduate student Tiffany DiPetta are working to develop a technology that detects damage to critical suspension components in military vehicles simply by driving over a speed bumplike "diagnostic cleat" containing sensors. The researchers have tested the system in experiments with high-mobility multipurpose wheeled vehicles, or HMMWVs, commonly known as Humvees. Credit: Purdue News Service photo/Andrew Hancock

Researchers have developed a technology that detects damage to critical suspension components in military vehicles simply by driving over a speed bumplike "diagnostic cleat" containing sensors.

"Our aim is to save time and maintenance costs, but more importantly to reduce downtime by catching damage before it leads to failure in the field," said Douglas Adams, an associate professor of mechanical engineering and director of Purdue University's Center for Systems

Integrity.

Purdue is working with the U.S. Army and Honeywell International Inc. to develop the technology.

The vehicles are driven over the "tactical wheeled vehicle diagnostic cleat," which is like a rubber-jacketed speed bump equipped with sensors called triaxial accelerometers. The system measures vibrations created by forces that a vehicle's tires apply to the cleat. Damage is detected in the tires, wheel bearings and suspension components by using signal processing software to interpret the sensor data.

"Let's say one of the tires is severely under pressure," Adams said. "The cleat tells you to turn around and fill up that tire because you are about to embark on a 10-hour mission with this vehicle. Or, you are returning the vehicle to the depot and the cleat tells you that the right rear suspension has a problem in the shock absorber or a critical bolt in the front suspension is broken. The maintenance personnel don't have to troubleshoot the vehicle. They know what to fix."

The system also could be used in commercial applications to test civilian vehicles, he said.

Research findings are detailed in a technical paper being presented April 22 during the Society of Automotive Engineers World Congress in Detroit. The researchers have filed for a patent on the technique, which has been nominated as a U.S. Army invention of the year by the Army's Tank Automotive Research, Development and Engineering Center, in Warren, Mich.

"The diagnostic cleat is designed to be quick and easy to use," said Joseph Gothamy, acting team leader for the reliability and durability modeling and simulation team at the U.S. Army center. "The last thing

we want to do is take time from already overburdened soldiers and maintenance officers. The cleat is a quick first check to determine what's mechanically wrong with a vehicle before wasting time hunting for potentially simple problems."

The technical paper was written by Purdue mechanical engineering graduate student Tiffany DiPetta, Purdue senior research engineer David Koester, Adams, and four researchers from the U.S. Army: Gothamy, Paul Decker, David Lamb and David Gorsich, from the Tank Automotive Research, Development and Engineering Center.

"Operating and maintenance costs for military weapon systems accounted for about 60 percent of the $500 billion U.S. Department of Defense budget in 2006," Adams said. "Better diagnostic and prognostic technologies could reduce this expense and ensure readiness of ground vehicle fleets."

By using the instrumented cleat and other "condition-based" maintenance methods, the military could reduce costs by performing work on vehicles when needed based on the condition of parts instead of performing scheduled maintenance on vehicles regardless of whether they need the work.

"In theatre, some vehicles may be used at checkpoints while others may be hauling supplies hundreds of miles," Gothamy said. "Even if the same vehicle variant is used, they are on very different missions and trying to use the same regular maintenance schedule for both isn't always efficient or effective."

The researchers tested their system in experiments with high-mobility multipurpose wheeled vehicles, or Humvees, and also developed a computational model to simulate how the system works.

"Our simulated model showed us that we were capable of using the system accurately to detect damage to vehicle components, and our experiments with actual vehicles validated the model," said Adams, whose research also uses facilities at Purdue's Ray W. Herrick Laboratories. "The system was sensitive to as little as a 5 percent change in the stiffness of the suspension."

Findings show the method is capable of accurately identifying damage to vehicle tires and the suspension. A damaged coil spring in the front suspension of a Humvee was detected even when tire pressure was varied widely in attempt to confuse the system.

"This system is currently ready to acquire more data in Army depots, and we are working with the Tank Automotive Research, Development and Engineering Center to start a large vehicle survey exercise with vehicles coming back from overseas," Adams said. "Data will be used to determine the types of wear and tear exhibited by vehicles deployed in certain terrains."

The system does not require specialized training to operate, and it is relatively inexpensive, costing about $1,500, which is spread across the inventory of about 20,000 vehicles, Adams said.

The research has been funded by the U.S. Army and Honeywell International.

Future research could focus on refining the signal processing software to more precisely identify specific components in the vehicle's suspension system.

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