GM Milford labs are where the software hits the road

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When most people think of General Motors Corp.'s Milford Proving Ground, they think of fast cars and oval tracks. They do not think of microprocessors or software flow charts. But this secretive installation is about much more than helmeted drivers putting the camouflage-shrouded prototypes of tomorrow's cars and trucks through their paces, and the engineers who watch with a mixture of pride and anxiety. It is also about small armies of coders pounding away at 500,000-line programs and chip designers navigating the highways and byways of a silicon wafer.

In addition to more than 130 miles of track crisscrossing the Livingston-Oakland county line, Milford is home to some of the world's most advanced automotive engineering laboratories. Most are dedicated to work with a fairly obvious connection to the automobile - corrosion control, vibration and crash safety. But one lab seems like it would be more at home in Silicon Valley than an automaker's playground.

GM Powertrain Controls is responsible for designing the onboard computer systems that control the engines and transmissions of GM cars and trucks. The group employs some 650 people, with many recruited from big-name technology companies like Motorola and Intel. Most are based at Milford, although some work at GM's Willow Run transmission factory in Ypsilanti Township or at GM Powertrain's engineering center in Pontiac. "What we think we bring to GM is an ability to bring technology into the vehicle, into the powertrain," said Jim Kolhoff, director of software engineering for the division.

Controlling the future

In 1979, when GM first started putting computers in its cars and trucks, that meant a simple computer connected to an oxygen sensor that adjusted the carburetor to meet new federal emission standards. Today, it means an array of computers fully integrated with each of the vehicle's systems that manage everything from engine displacement and transmission fluid pressure to adaptive cruise and stability controls.

Over the past decade, they have received 297 patents for their work.

In 1979, the first onboard computer developed at Milford controlled six major vehicle functions. Today's onboard computers manage more than 100. The microprocessors in today's systems are 56 times faster than those first used by the company and boast 500 times as much memory. Moore's Law - the axiom stating that computing power doubles every couple of years - applies to automobile computers as well as to desktops.

However, unlike their desktop counterparts, these computer systems must be able to stand up to some of the worst operating conditions imaginable. Because these controllers are mounted on the engine or in the transmission, they are exposed to fluids, vibration and temperatures that would quickly destroy even the most rugged laptop. Today's automobiles cannot function without these systems, and there is no reset button to hit if they fail.

"A reboot is a walk," said Dennis Bogden, director of electronics engineering. "We (also) have to make sure these things can last for 15 to 20 years. It becomes a real technical challenge, especially because we want real low-cost systems as well." Rather than design new computer systems for each new car and truck, GM's engineers strive to develop flexible, modular systems that can be used on a variety of vehicle platforms. They also strive to create systems that can be produced by multiple suppliers. "It allows us to find the best price," Kolhoff said.

Today, these efforts have coalesced into three engine control systems and two transmission control systems. Combinations of these five systems are used on every car and truck GM makes. Adding or removing sensors and activators allows engineers to create distinctive performance and feel for each vehicle.

"We can make a Buick feel like a Buick, a Cadillac feel like a Cadillac and a Pontiac feel like a Pontiac," said Audley Brown, director of controller integration and applications. While some of these advances add to vehicle cost, many actually reduce it. For example, using computers to manage the combustion process allows GM's engineers to use less precious metal in their catalytic converters. Moreover, today's controllers do more and cost less than their predecessors.

Although GM would not disclose the cost of these components, company spokesman Nick Richards said they represent between 8 percent and 10 percent of the total cost of each vehicle's powertrain.

Software expertise

All of the software that controls these systems is written in-house by GM's own software engineers. They work closely with the Software Engineering Institute, a federally funded research lab at Carnegie Mellon University in Pittsburgh, allowing them to stay on top of the latest advances in fuzzy logic and neural networks. All of these technologies have found their way into GM's onboard computers. GM's engineers are also getting more directly involved in the design of the chips themselves, thanks to a new alliance announced last year with Freescale Semiconductor Inc.

The typical controller takes three to four years to develop and has a production life of just three to five years. Because work on the microprocessor must begin before engineering the actual system, some of the engineers at Milford are already working on chips for controllers that will not find their way to showrooms until 2012.

The same technology that goes into these powertrain control systems has also revolutionized the way they are built and tested. Most of the design and testing at Milford today relies heavily on computer simulations and modeling. Using computer systems developed by Ann Arbor-based Applied Dynamics International, Brown said, GM's engineers are able to simulate any vehicle under any driving condition.

This has greatly decreased the time it takes to develop and refine new components because testing can go on around the clock, regardless of the weather outside the lab. Inside the computer, it is always summer - or whatever season the engineers want. They can even input data collected by survey vehicles to simulate any road, anywhere in the world.

Kolhoff said engineers used to have to write software and then go out and test it in a vehicle on the track to make sure it worked. "We would have been in and out of the vehicle many, many times," he recalled. "(Now) it's all virtual."

Next generation in the works

Of course, the track still has a role to play, but it is increasingly one of final validation. According to the engineers at GM Powertrain Controls, the future promises even more advances, as well as plenty of new challenges.

The engineers at Milford are already putting the final touches on a new generation of engine controllers that will shut down cylinders when they are not needed and activate them when they are. For example, if you have a six-cylinder sedan, you probably do not need all six of those cylinders firing to maintain a comfortable highway cruising speed. However, you want them when it comes time to pass that semi. Known as displacement-on-demand, this technology promises to yield big increases in fuel economy while lowering emissions.

GM's OnStar wireless communications technology will become standard on all GM vehicles sold in the United States and Canada by 2007. The widespread use of this system has opened the door to remote diagnostics, allowing mechanics to identify problems with a vehicle before it ever enters a shop. That, coupled with the introduction of wireless sensors using the same Bluetooth technology employed in cellular telephones and personal digital assistants, promises to change the way mechanics interact with automobiles.

Powertrain controls become even more important, and more complicated, in hybrid and hydrogen fuel-cell vehicles. The Milford team is already working closely with GM's fuel-cell researchers on tomorrow's hydrogen-powered cars and trucks.

"We intend to remain on the leading edge," Kolhoff said.

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