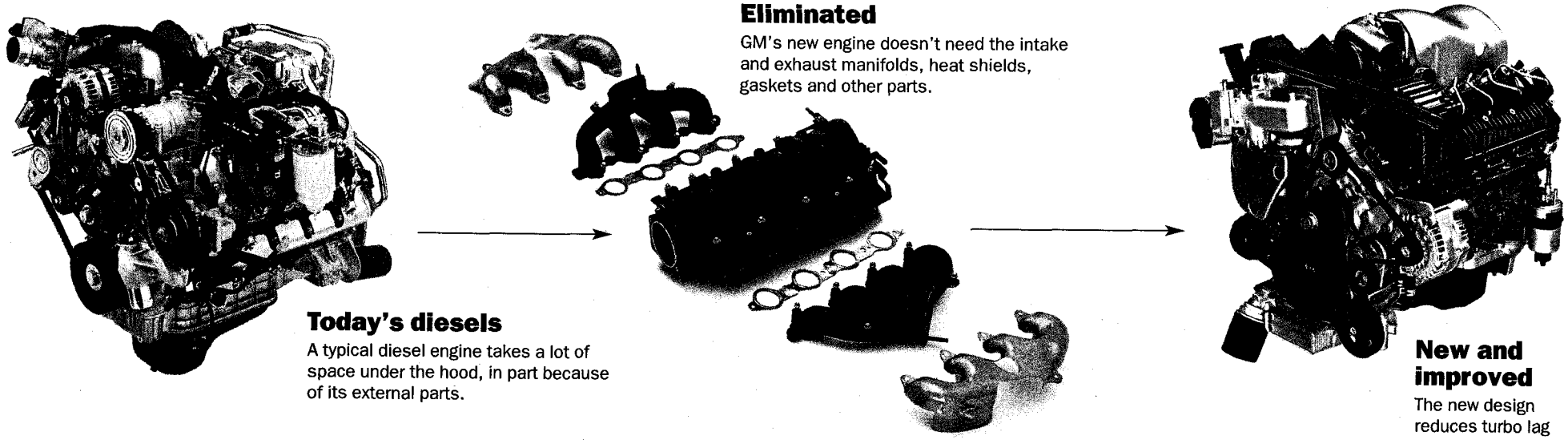

Today's diesels
A typical diesel engine takes a lot of space under the hood, in part because of its external parts.

Eliminated
GM's new engine doesn't need the intake and exhaust manifolds, heat shields, gaskets and other parts.

New and improved
The new design reduces turbo lag and saves weight, space and up to $600 per engine.

Redoing the diesel

GM's radical 2009 design cuts cost and weight, saves space under the hood

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DETROIT — In late 2005, Charlie Freese and Gary Arvan sketched out a radical new design for a diesel engine.

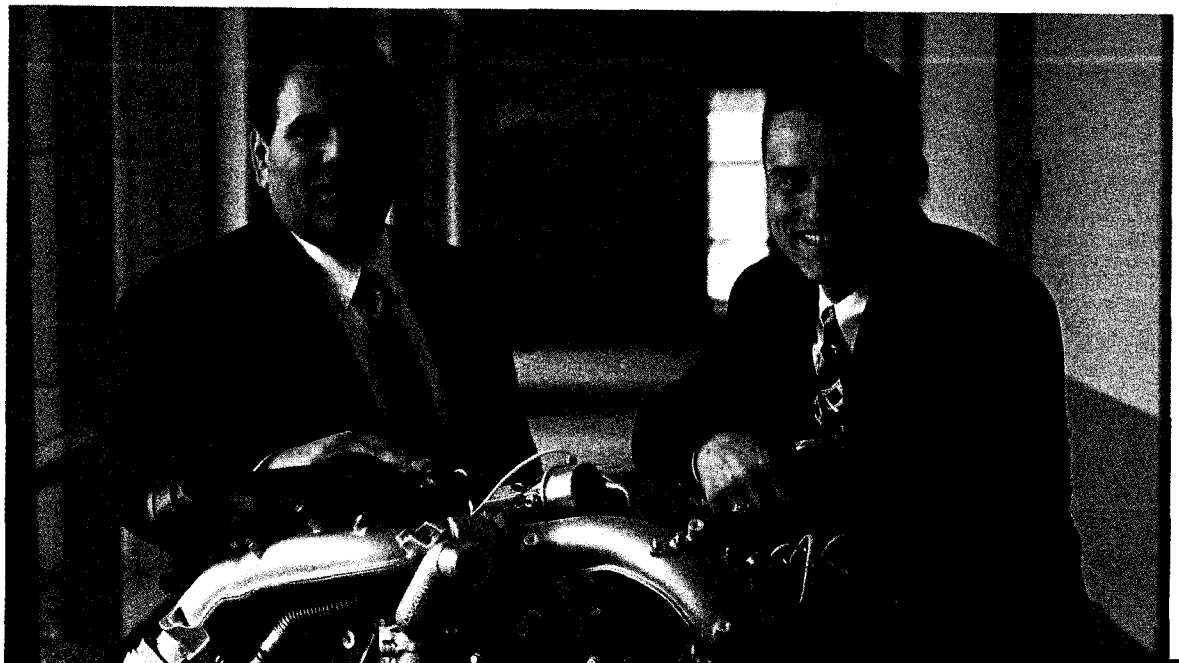
On paper, it could eliminate about two dozen parts, slash the high cost of diesels and save space, too.

Two weeks later, the two General Motors engineers stood before senior managers from GM's Powertrain division, seeking approval, and millions of dollars, to develop the design.

The payoff, all knew, could be huge.

Coming to America

Diesels, which can be about 25 percent more fuel-efficient than gasoline engines, are poised to power more U.S. cars and trucks. Diesels already power half of all new cars in Europe. Virtually all European and Japanese automakers plan to introduce diesels in the United States around 2010.



Freese argued that GM could help

parts. GM won't have to buy those parts from suppliers, or design, test and validate them. GM also should save money on the assembly line. With fewer parts, the engine can be built faster, with less labor.

GM won't say how much it will save per engine, but Freese acknowledges the savings will be big. Others estimate that GM's savings per engine in parts costs alone will likely be around $100.

The compact design also solved a space problem. GM wanted a V-8 diesel that could fit in the same space as the small-block V-8 gasoline engines in the Chevrolet Silverado/GMC Sierra pickups, and in the Chevrolet Tahoe/GMC Yukon SUVs. Narrower than a regular diesel of the same displacement, the new engine fit.

For all of its size, weight and cost advantages, it was the engine's performance that finally mattered.

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Freese argued that GM needed to risk the radical engine makeover. "In today's auto industry, you can't afford to develop an average anything. You can't set your goals that you want to be like everybody else," he says.

The top brass peppered Freese and Arvan with tough, detailed questions about heat, sealing, flow, packaging, manufacturing and costs.

The key question: Would this design really work? After all, the design broke many of the rules in GM's engine design handbook.

Freese, 39, executive director of GM's diesel powertrain engineering, and Arvan, 41, chief engineer for the GM Duramax diesel engines, already had grappled with many of those questions. In some cases, though, they needed more studies.

The more he heard, the more GM Powertrain boss Tom Stephens was intrigued. He told Freese and Arvan to do more research to verify their design.

Using GM's supercomputers, Freese, Arvan, and other engineers watched the engine take shape on screen, looking inside the virtual engine as it ran. They were measuring such things as heat, flow and stress.

Never before

The data were critical, because nobody had seen a production engine like this before. The proposed engine's design reverses the flow of air and exhaust gases going in and out of the cylinder heads.

On standard V-8 engines, fuel and air enter on the side of the cylinder heads facing the inner part of the "V." The exhaust gases exit on the V's outside.

In Freese and Arvan's design, air enters the engine through ports in the outer portion of each cylinder head. The exhaust gases then exit inward between the cylinder heads and directly into a turbocharger.

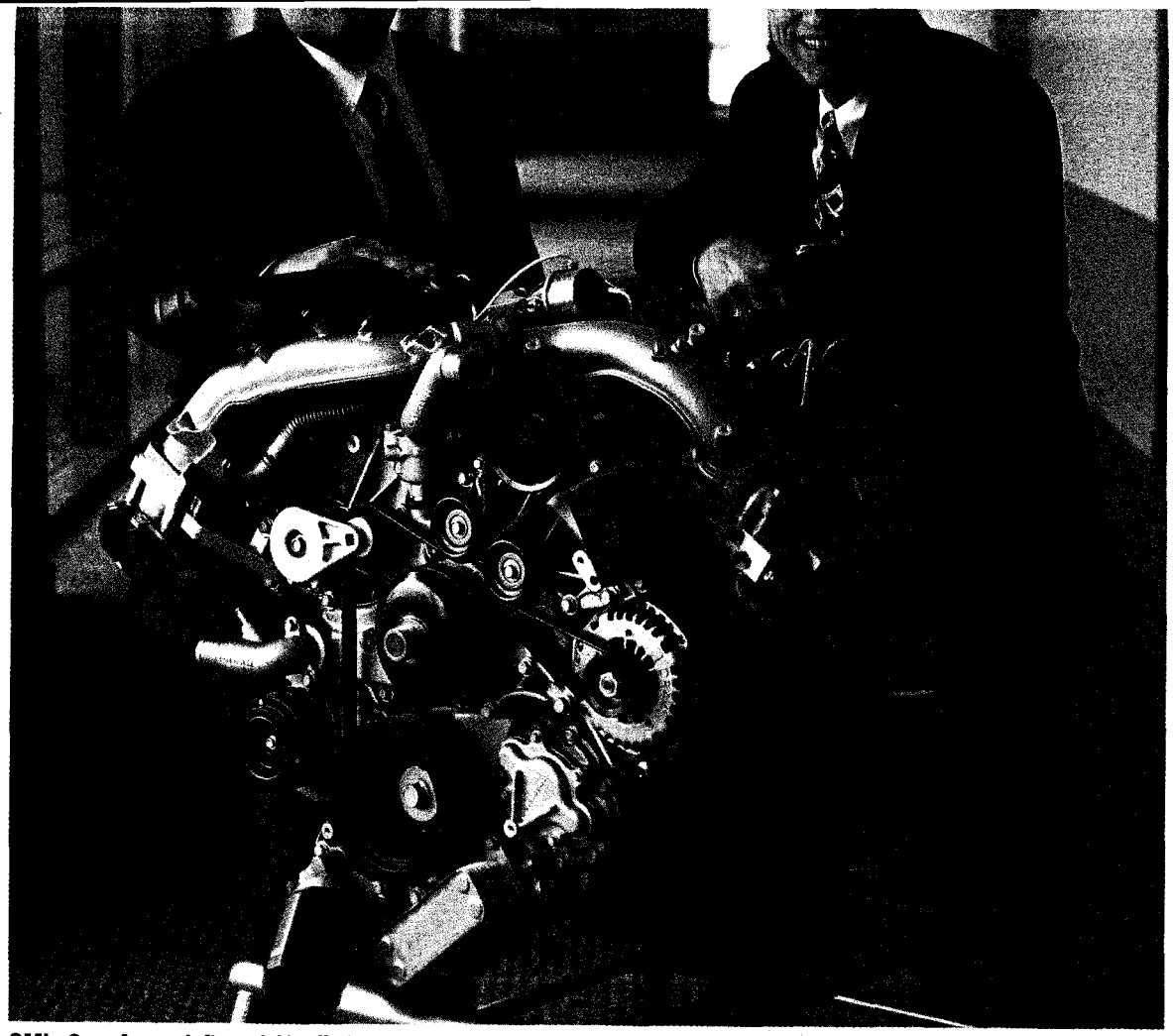
That eliminates numerous parts, saves space and lets the engine make more efficient use of heat. All of that improves fuel economy and performance, reduces noise and lowers emissions.

Because diesel exhaust is as much as 100 degrees cooler than the exhaust from a gasoline engine, having the exhaust in the center of the engine shouldn't cause problems, said John Heywood, a diesel engine expert who teaches at Massachusetts Institute of Technology.

Some elements of the new design have been tried on race car engines, but there has never been a regular production car engine designed this way.

"It's a radical evolution" of the internal combustion engine, says analyst Jim Hall of AutoPacific Inc., a Tustin, Calif., consulting firm.

The new engine eliminates the bulky intake manifold, two heavy cast-iron exhaust manifolds and related parts such as gaskets, bolts, nuts, studs and most heat shields.



GM's Gary Arvan, left, and Charlie Freese sketched out a dramatically different design for a diesel engine, and then convinced General Motors to build it.

Savings: Up to $600

The new design could shave $350 to $600 off the cost of producing the engine, Hall estimates.

Given diesel's high costs, that is huge. "Day one, when you start a diesel program, you are already in cost trouble," says Arvan.

The savings, Hall says, come in a number of areas. First, GM will save money by eliminating the two dozen per engine, but Freese acknowledges the savings will be big. Others estimate that GM's savings per engine in parts costs alone will likely be around $100.

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Less than a year after Freese and Arvan's pitch, GM CEO Rick Wagoner, Vice Chairman Bob Lutz and Stephens test drove the first running versions of the engine at GM's sprawling Milford, Mich., proving grounds.

Emerging from a test dark-blue Buick Rainier engineering mule, the three senior executives were amazed at how smooth, quiet and powerful the new diesel engine ran.

Disbelief

"The first thing that came to everybody's mind was a little bit of disbelief," recalls Freese. "It was so quiet. And it had such a high level of performance for the size of the engine and the vehicle it was in."

The top brass approved the new diesel engine for GM's light-duty trucks. It is scheduled for production in 2009 at a revamped plant in Tonawanda, N.Y.

The new 4.5-liter Duramax turbodiesel V-8 is a double-overhead-cam design with four valves per cylinder. It will develop at least 310 hp and 520 pounds-feet of torque. It will be sold in all 50 states and will be the first GM engine that will use urea injection to control emissions of oxides of nitrogen.

If the engine performs as GM expects, it could change the way diesels are designed and viewed. But Freese will be happy if buyers don't think about what it means for diesel design.

Says Freese: "My measure of success won't be if people say, 'That is a really great diesel.' They just need to say, 'That's just a great engine.' " AN