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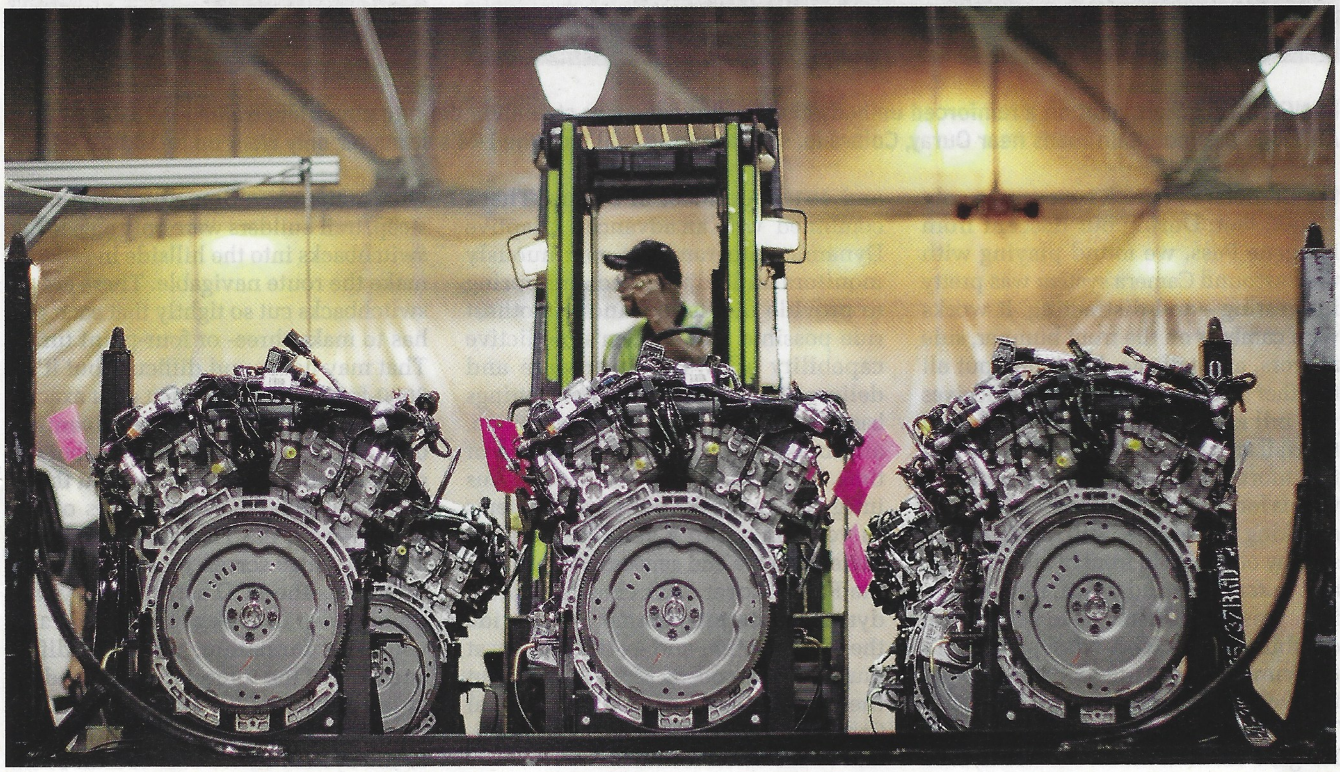
Truck Vehicle Development

The critical path from prototype to production

Story by **Gary Witzenburg**



Some engineers spend endless hours on computer-aided engineering (CAE) tubes, designing every component of every car and truck that hits the road. Others toil equally hard in the manufacturing end of the business, where those thousands of parts and pieces come together. And a select few work the critically important process in between, called vehicle development (also known as integration). These dedicated engineers divide their long working hours among computers, communications, and vehicle testing on proving grounds and public roads. Not that many years ago, development engineers were involved primarily in early preprototype and preproduction vehicle levels. Today, they are typically involved from a program's very beginning through production launch, if not beyond.

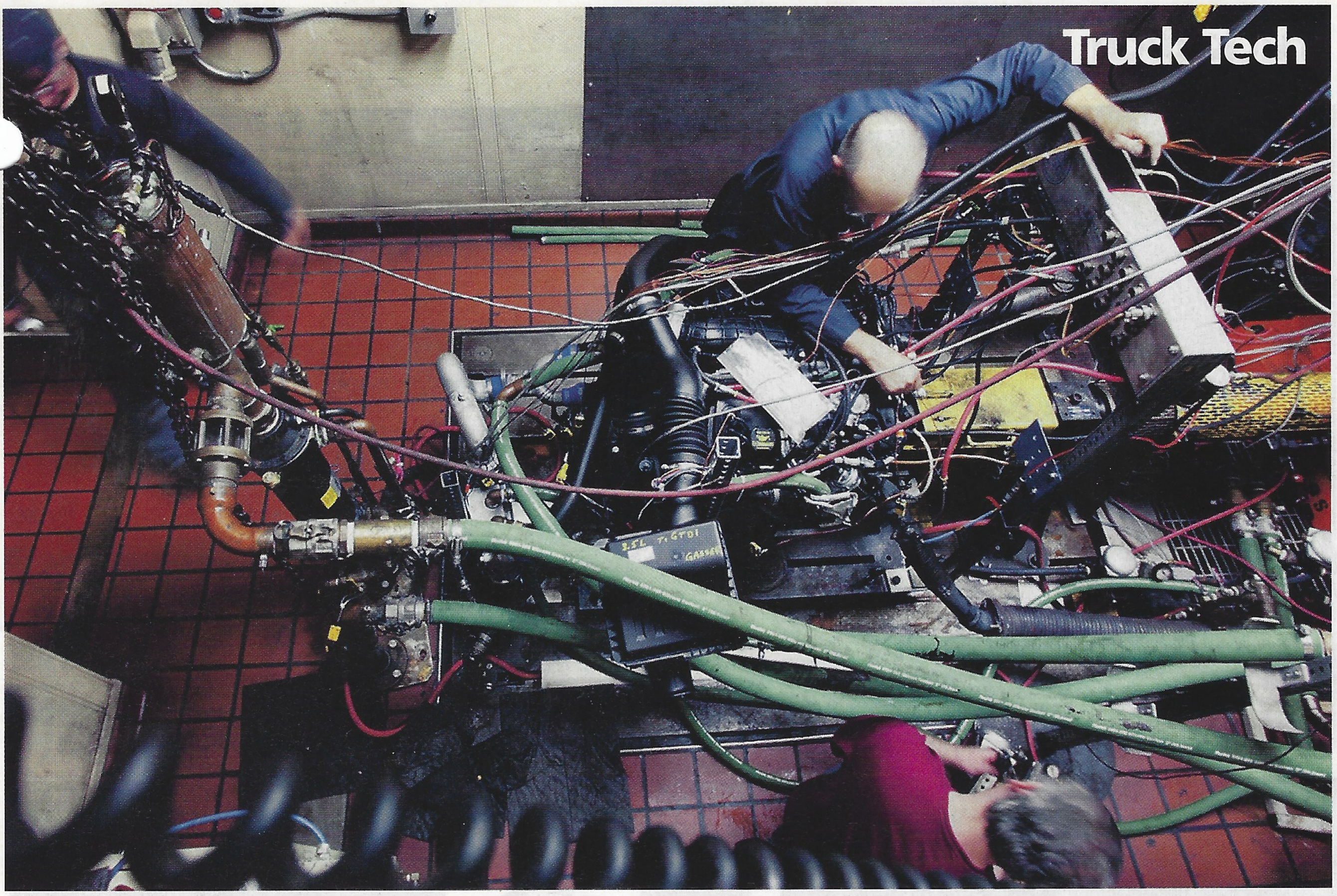
THE PROCESS

Each vehicle design begins as a thick package of performance requirements, targets, and technical specifications. Beyond the basics of how long, wide, tall, and heavy a vehicle will be—and, for trucks, how much it will tow and haul—is a long list of customer satisfaction metrics: performance versus fuel efficiency, ride versus handling, interior roominess, noise levels and much more. Each target area is specified as a set of quantifiable numbers based on whether the vehicle's maker intends to be segment-leading in that area, or simply competitive.

And every vehicle is an assembly of subsystems—including body, chassis, interior, electrical, and powertrain—and each of those is a complex set of individual parts and components. Once the target specs and requirements are in place, product delivery teams (typically including finance and purchasing specialists; design, development, and manufacturing engineers; and, in some cases, key supplier representatives) set about designing, developing, validating, and delivering the parts and components necessary to meet them.

"Our job is to broker how all those parts come together into the complete vehicle," says Ford F-150 Vehicle Engineering Manager Jeff Lewis. "We don't own any parts; we deliver attributes and integration. Dawn [Piechocki] is the supervisor responsible for vehicle integration, which looks at key customer attributes and defines the targets for each attribute. She is also involved with conflicts, tradeoffs, and optimizations among attributes to get to the optimum solution."

In addition to the basics of powertrain performance, chassis dynamics



WHILE MUCH of a vehicle's development still requires testing prototypes on the road, a lot of the upfront development is done in the lab, with computer aided engineering.

(ride, handling, steering), and NVH (noise, vibration, and harshness), those attributes include thermal (heat management, cooling, climate control), package (ground clearance, ramp angles, passenger ingress/egress), safety, fuel economy, squeak and rattle, aerodynamics, off-road, trailer tow, and brakes. "Brakes has become an interesting one," Lewis says. "It has expanded into traction control, stability control, anti-sway, and hill descent management."

LABS AND TUBES

Unlike the not-so-old days when vehicle development was mostly done in various levels of development vehicles, today's development/integration engineers accomplish most of their work in labs and on computers, with maybe just the final 20-25 percent behind test vehicle wheels. Once the subsystem teams have specified what they need to meet their requirements, the vehicle engineering team runs the entire vehicle in the form of a CAE computer model through an exhaustive program of analytical testing to learn how it performs and what changes are needed before the first prototype vehicles are built. "Then, when the hardware shows up, those same engineers test it to find out if it's where it needs to be," Lewis says, "and, if not, what they need to modify to get there."

Piechocki says the amount of time she spends in vehicles depends on where the program is in the process. "If the NVH or dynamics team tells us they're close to achieving their targets, we'll spend more time in vehicles with them, potentially up to 50 percent of our time."

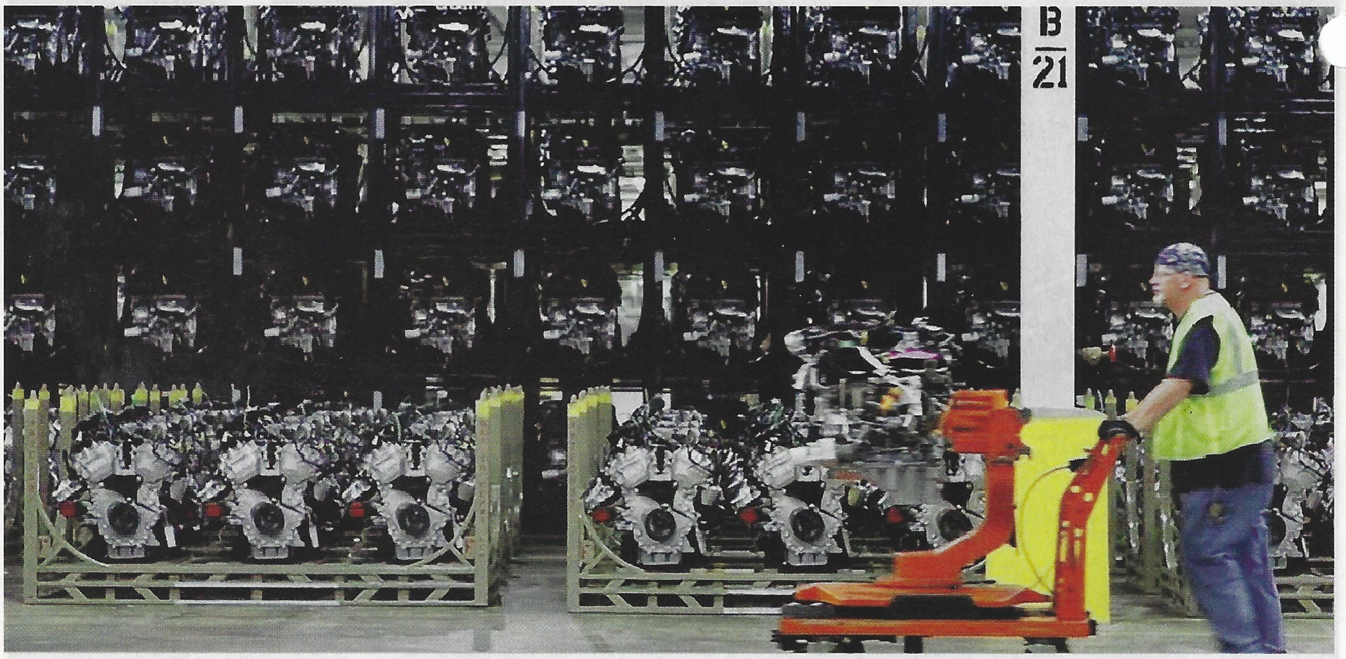
Lewis explains that in-vehicle engineering time is much less than it used to be: "One reason is that our analytical tools have improved significantly, which has allowed us to reduce the number of vehicles we build, and hence the amount of time we spend in them. The other is that, as a company, we are a lot clearer on where we want the vehicle to be out of the gate.

"Ten years ago, we would've spent a lot of time in vehicles deciding where we want an attribute to be instead of actually delivering that attribute. Now, by the time we get the hardware, we've projected where we think the competition will be and we're squared away and in agreement on where we want to be. The only time we spend in vehicles now is to ensure that we actually deliver what we targeted."

FROM START TO FINISH

Jim Mikulec, GM's lead development engineer for heavy-duty pickups, explains that his group is involved in vehicle programs from beginning to end. "We do total vehicle integration, which means we take all vehicle subsystems and integrate them into the total vehicle. We start at the advanced vehicle stage and set all the technical specifications for light- and heavy-duty, gas and diesel. Then we do most of our [in-vehicle] work in chassis development (including tires, shocks, and all tuning elements) and NVH (powertrain, wind noise, road noise, and acoustics), plus fuel efficiency, drive quality, and all stopping requirements. I look at our group as representing the customer through the whole design and development process, and I have folks who specialize in all those areas."

Several years ago, Mikulec relates, GM had an initiative called Road To Lab To Math, a concerted effort to move as much vehicle development as possible from expensive prototype vehicles to lab facilities and ultimately to CAE tubes. "For example," he says, "We used to do an incredible amount of testing at altitude in Denver, but now we've taken a lot of those tests into



THE ENGINEERS' goal is to develop a long list of performance requirements, specifications, and targets, as well as customer needs and the manufacturers' requests, into a segment-leading vehicle. Trucks are tested in labs, on the road, and at proving grounds.

chambers with dynamometers where we can vary barometric pressure. That gets you close to the final answers for engine, transmission, and emissions calibrations.

"For safety and crashworthiness, we used to have at least 100 vehicles running barrier tests. We have only a fraction of that now because most of that work is done mathematically, though the final testing has to be done with physical properties. For chassis development, kinematic models help us get to the final answers a lot quicker. Climactic wind tunnels let us test from -22 degrees to 120 degrees F, do rainstorm development, even snow ingestion. Acoustic models help us develop interior panels, and computational fluid dynamics math models do exhaust system sound development. We still do a lot of vehicle testing, but a lot less than we used to."

One other area is full-vehicle "validation," which used to be conducted with large fleets of vehicles running durability tests. Much of that is now done in labs and with math models, so automakers have to run just a fraction of the vehicles they once did.

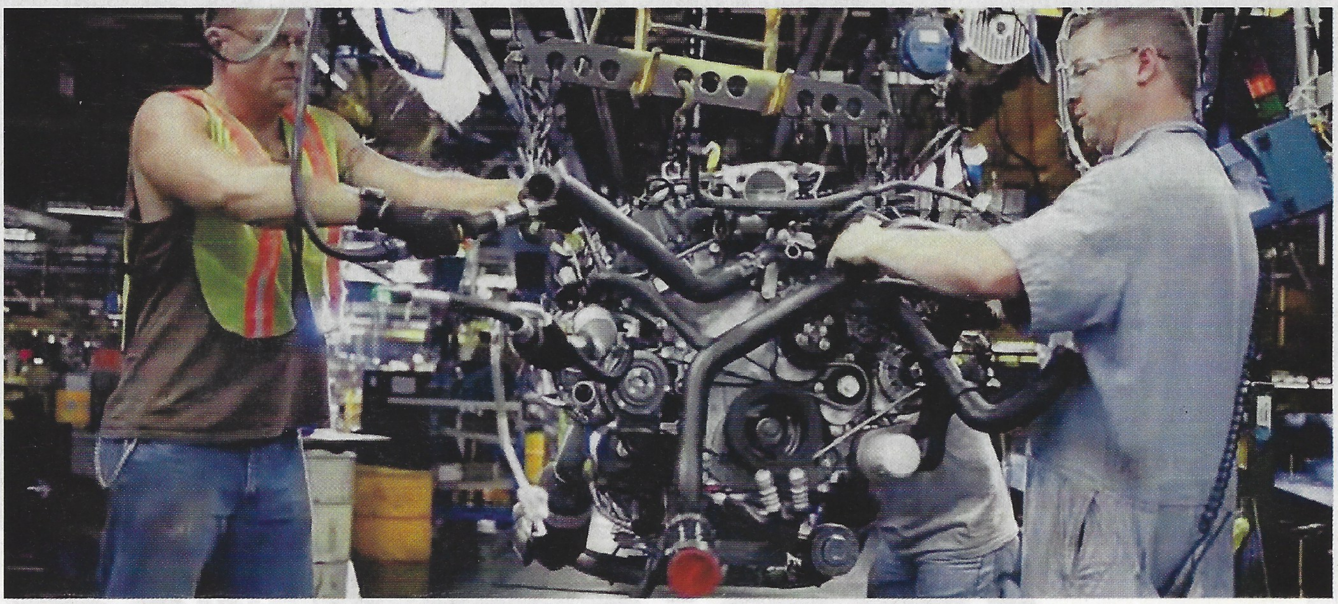
"When you look at prototype costs," Mikulec says, "each vehicle could be a quarter of million dollars. We've eliminated a lot of that, which has helped us cut the time to develop a program."

RAM CHALLENGES

Kevin Mets, responsible engineer for Ram Truck heavy-duty pickups, tells us that achieving balance among the widely diverse variations of Ram trucks may be his group's toughest challenge. "Our product line spreads from 1500 all the way up to 3500 chassis cabs," he says. "The 1500 guy has an occasional need for pickup applications. He uses it for daily commuting and hobbies. The 3500 dualie guy uses it for his construction business and pulls his flatbed or gooseneck trailer with a backhoe on it. So the customer base is huge."

He agrees that the bulk of vehicle development today is done very early in the process. "When we launched the new 2009 truck, we knew we needed all the capability we could get and needed to improve our cab appearance and comfort, and we used CAE tools to go for the really innovative breakthrough of implementing rear link-coil suspension. We used kinematic models to understand all the suspension hard points and see how the vehicle would behave in dynamic settings.

We also used CAE modeling for NV. development to ensure that we isolated the customer from shake, beaming, and vibrations. So we had that vehicle pretty well locked in before the first prototype,



THERE IS no substitute for road tests. These help confirm the findings engineers discover in the lab. They also determine how good a job a truck maker has done of balancing ride and handling, and fuel economy and performance.

and from there it was a refinement process."

Mets adds that CAE enables engineers to do more iterations in working through all the various configurations. "Think of all the different configurations of a pickup truck," he says. "For a 1500, we have three different cab styles, different wheelbases, different engines, two- and four-wheel drive, different tires. If we need to make tweaks and changes, we can use the modeling tools to see what the effects would be on the other variations. There is less invention and more refinement going on between that first prototype and production."

Toyota, too, says the bulk of its vehicle development work is carried out via CAE and in laboratories instead of in expensive early development vehicles. Not surprisingly, all "upfront" (pre-vehicle) development is done by CAE, then vehicle-derived confirmation and correlation is fed back into the CAE models for process improvement. Beyond chassis dynamics and NVH (which Toyota typically does concurrently), this work also includes "human factors" and ergonomic evaluation and improvement. Toyota says the most significant challenge facing its truck development/integration engineers today is resolving difficult trade-offs to balance oft-competing factors such as cost, mass, and performance.

Highly effective vehicle development is increasingly important to achieving world-class quality, reliability, durability, and customer satisfaction immediately out of the box for each new vehicle—as opposed to achieving it two or three years down the road. While 75-80 percent of this work today is done in labs and on computer tubes, there will always be a demand for skilled engineers with "calibrated butts" to test development vehicles on proving grounds and public roads for final refinement of chassis dynamics, NVH, and more. No matter how advanced automakers' engineering tools may become, they will always need the human touch and feel. ***TT***