of variations in a fraction of the time and cost that would be required for testing with physical prototypes.

Unlike physical wind tunnels, where design development is mostly sequential, i.e., a series of trial and errors to incrementally improve a design, the virtual process also allows exploration of a much larger design space using DOE (Design of Experiment) optimization tools coupled with a “Digital Clay” process that offers parametric modification or morphing of design surfaces.

We made extensive use of both—applying the latter on large surfaces, such as the trailer boat tail panels, to find the optimum length, position, and angle of the panels. While the sequential approach was used mostly to iterate on the tractor design—meeting the engine cooling need while minimizing its aerodynamic impact (also known as cooling drag), shaping the front end around the cooling package and in general, minimizing obstructions to the airflow as it makes its way around the tractor-trailer system.

A unique advantage of the Supertruck project is our ownership of the complete system—from the bumper to the boat tail—which, in turn, offers us unique synergies. For example, by
mating the chassis fairings to the trailer skirt, we were able to completely cut out pathways for airflow to enter under the tractor-trailer from the sides. This allowed us to design an effective air dam under the front bumper which minimized air getting under the vehicle and creating additional drag as it encounters low-hanging chassis components. This would not be as effective without an aerodynamic trailer as the suction created by the air dam under the vehicle would draw in air from the sides and increase the drag on the trailer bogie. It’s a little-known fact that almost half of the aerodynamic drag on a modern tractor-trailer system is generated from the trailer base (door) and the trailer bogie. This is why trailer aero devices (skirts and boat tails) are so effective in reducing fuel consumption for large fleets.

Unlike physical testing, our virtual experience twin process offers detailed visual insight about the airflow around the vehicle. This is critical as it drives our iterative design process—every design change is based on learnings from the previous iteration, thereby continuously improving the aerodynamics until we reach saturation or diminishing returns. After hundreds of tweaks and dozens of iterations, we were able to reduce the overall aerodynamic drag of ST1 by 40%, yielding a 20% direct improvement in fuel economy. But there were indirect benefits as well.

At a cruise speed of 65mph, almost half of the road load on a tractor-trailer comes from the air resistance or aerodynamic drag. Therefore, by drastically reducing the drag, we were able to downsize our engine—from a 13L 485HP in the baseline to a 11L 425HP in ST1. This reduced the weight of the tractor (thereby increasing payload and therefore, freight efficiency) and lowered the engine cooling demand from what was originally anticipated, which meant we could use a smaller cooling package. This resulted in a narrower hood, smaller grille opening and a much lower cooling drag.

On the heels of the success of ST1, the DOE initiated the Supertruck II (ST2) program in 2016 and doubled the challenge—to achieve 100% improvement over the same 2009 baseline. The project is still on-going as we enter the final, build phase. However, the tractor-trailer design was frozen a while back, a culmination of a similar process as ST1 powered by the same virtual experience twin technology. This time, we reduced the overall drag by 50% over our 2009 baseline—almost 20% over ST1.
Coupled with the improvements achieved by our powertrain colleagues, Volvo’s ST2 is expected to deliver a 120% improvement over our baseline, achieving 220 ton-mpg. The validation of our virtual experience twin results with the physical prototype, currently under construction, should happen in the coming months.

As a demonstrator, Supertruck is similar to a concept car; while many of the improvements already are, or soon will be, incorporated into our commercial offerings, others need more work to bring down their cost. And Supertruck II isn’t the end of the journey: the recently announced Supertruck III program will focus on battery-electric and fuel-cell-powered vehicles—the designs that will move the trucking industry from a transitional period of lower tailpipe GHG emissions to one with zero tailpipe emissions.

