ALLIANCE FOR AUTOMOTIVE INNOVATION

FROM IDEA TO PRODUCT: AUTOMOTIVE MANUFACTURING 101

A new car on sale today began with an idea as much as five years ago. Engineers and designers then turned that idea into a working prototype that began testing three years ago. At the same time, the automaker was already deciding where and how the car would be built, and who would build it.

For the next year or two, the prototypes might be driven as much as a million miles each, or the equivalent of circling the globe forty times. They would be sent to the Arctic Circle and Death Valley to see how they performed in extreme conditions. The engine's durability will be tested by running it at its red-line non-stop for the equivalent of 100,000 miles. Systems and components will be pushed to the breaking point, all to be sure that the car performed whenever and wherever it might be needed.

During this time, the car's safety and emissions systems would be tested to ensure they met all regulatory and company requirements. Cars would be crash-tested from the front, side, roof, and rear, using crash test dummies that come in eight different sizes ranging in cost from $130,000 to $1,000,000 each. As many as 400 virtual tests and computer simulations, accounting for 192,000 hours, would be conducted, along with more than 11,000 real-world physical tests conducted by suppliers and manufacturers. The testing would determine the sources and solutions of noise or vibrations, and lead to strategies for optimizing fuel efficiency, for reducing weight and waste, and for improving safety margins. The tests also explore how drivers respond and react to new features, such as automatic emergency braking, and collision and lane change warnings. If the testing reveals issues requiring redesign or reengineering, more tests will likely be needed to validate the changes.

Once all benchmarks have been met, the car is set for production more than a year before it will appear in dealerships. Production of "job one"—the very first car of the new or redesigned model—at the factory begins six months before the car goes on sale to ensure that the rollout goes smoothly.

And one more thing: to succeed in the market, that vehicle has to improve upon the model it replaces in every way. It has to be more efficient, safer, and equipped with the latest innovative technologies.

As one auto journalist put it: "The idea of a truly all-new car is tempting fate. Each system, each individual component, requires so much effort to work properly in concert with a thousand other components, in myriad conditions… Doing it all at once is an expensive gamble."[1] That gamble involves thousands of people, as much as five years, and up to $5 billion.

Bringing a car to market also requires an extensive, and expensive, support network. Each new product can require the conversion of 100 U.S facilities for vehicle assembly, stamping, and powertrain (engine and transmission), and for the components produced by suppliers and by the suppliers to those suppliers. The huge amounts of capital required lead to long product life cycles so that a manufacturer can recoup that investment and fund more innovative products and features, making vehicles cleaner, safer and smarter.

These R&D and manufacturing challenges have grown more complex in recent years given the pace and spread of innovation. Automakers will invest $250 billion by 2025 to electrify their passenger vehicle fleets and install life-saving technologies that help drivers avoid collisions and accidents.

[1] Jeff Koch, July 2021 issue of *Hemmings Classic Car*.

Innovation in vehicle electrification and automation is requiring automakers to make fundamental changes in every aspect of their operations:

- **Raw materials:** The electrification of the vehicle fleet is going to require reliable, sufficient and affordable supplies of lithium, cobalt, silicon-graphite, and other rare earth and polymer materials, from approved and sustainable sources.
- **Components:** A shortage of semiconductors has already forced manufacturers to suspend production of popular and profitable vehicles, and limited their ability to equipvehicles with the latest fuel saving or safety features.
- **Production facilities:** In the past, manufacturers could carry-over assembly plants and component factories to new/updated models and trim-lines, making continuous improvements in engines or transmissions. Vehicle electrification and automation require all-new supply and value chains. New materials, including ultra-high strength steel, aluminum, or advanced composites that reduce vehicle mass and improve efficiency, require expensive new factory production tools such as increased capacity body stamping equipment to form ultra-high strength steel or autoclaves and other specialized tooling to manufacture advanced composite parts.

Instead of fuel tanks, starter/generators, differentials and exhaust treatment systems, cars will have batteries, charging sockets, motors, and power inverters and converters. At the moment, a great amount of this capacity is located in Asia. That's why many automakers are investing in their own battery production facilities in the United States. Six states (Tennessee, Nevada, Ohio, Michigan, Georgia and Texas) are currently home to new battery factories, and seven more plants have already been announced.

Future success rests on managing and wherever possible, aligning, a number of variables:

- **Consumer preferences:** Consumers expect high levels of utility, performance, comfort, safety, and more. They need to trust, and understand, automotive innovations, such as driver assistance systems.
- **Government requirements:** New mandates or requirements have to be affordable, achievable, and economically sustainable. For example: half of all vehicles in the United States lack a reserved off-street parking space where a charger for an electrified vehicle can be installed. The lack of a charging infrastructure – and clean power sources –could seriously delay the transition to a fully electrified vehicle fleet.
- **Economic and resource constraints:** Manufacturers have enormous, but not infinite, finance, technical and manufacturing capabilities.

It all comes together as part of a complex, rigorous and challenging cycle that results in one groundbreaking innovation after another. And the reward goes to the customers. Customers who have more choices and more products with ever advancing technologies.