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WHY CARMAKERS ARE RACING TO GO DIGITAL

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AUTOMOBILE MANUFACTURERS ARE HITTING a wall of complexity that's shifting efforts to modernize engineering departments into overdrive, pushing them to adopt digital technologies to streamline work, improve collaboration, and contain costs.

New cars are essentially rolling computers, with up to 100 processors controlling systems large and small. It's not uncommon for research and development for a new model to take about five years and cost up to $1 billion. In the past decade, software-powered systems have grown to account for up to half of those costs. To function, features such as automatic braking and advanced driver assistance services (ADAS) have to interact with multiple other systems, necessitating changes to all of them. Just adding ADAS to a new car model increases the complexity index by 22%, according to 2016 research by IPG Automotive and the Munich University of Applied Sciences.

While cars' electronics and digital-based functions have multiplied, however, engineering departments have been slow to use digital tools to build them, a sign of how entrenched practices can become in a mature industry. But maintaining the status quo is no longer an option. Engineering must adopt digital processes and tools now to keep up with developments such as autonomous-vehicle technology. And they must act sooner rather than later to address competition from fast-growing startups and competitors from the tech industry with deep experience in software development.

Digitizing engineering processes involves tools that directly affect the car, such as virtualization, data from connected cars, and artificial intelligence (AI). Others tools, such as cloud-based collaboration platforms, improve how engineering personnel communicate and collaborate. Automakers that have embraced these technologies have realized multiple benefits, including cuts to upfront engineering and materials costs and to the time needed to bring a new model to market. The benefits continue after a car is sold by minimizing the number of vehicles returned to dealers with warranty issues.

Options for Digitizing Engineering

Digital technologies can improve all stages of engineering, from predevelopment, when a new model's features and functions are determined, through design, testing, production, and diagnostics that engineers can use after the fact to continue fine-tuning their work. (See Exhibit 1.)

Virtualization. Automakers have used computer-generated simulations for close to 40 years to design, test, and build new-model prototypes and components. But these simulations and the data they yield have not been consistently reliable, and the data has not been shared across engineering IT systems. As a result, engineers still use many manual methods. In product testing, for instance, it's not uncommon for companies to build up to 500 prototypes—many by hand—to prepare a new model for mass production.

Recent breakthroughs in processing power and algorithms, however, have led to virtualization technologies that make simulations cheaper and more reliable. Virtual reality, augmented reality, 3D printing, and "digital twins"—models that mimic real-world products and processes—are valuable tools for engineers. These technologies make it easier to detect design mistakes early on, which reduces late-stage errors that can stall the advance of a new model through design and testing.

Virtual technologies can be applied to multiple product- and process-testing situations. In product design, for example, they can be used to test acoustics, hydrodynamics, and electronic systems, and in crash tests. 3D-printed parts are less expensive to produce, so using them to create prototypes of subsystems can lower overall prototyping costs. In advance of a new model's "body in white" manufacturing phase, when sheet metal components are bound together, simulations can be used to test the feasibility of making welds in hard-to-reach places. Virtualization can also simulate other stages of assembly-line work to prevent problems before they hit the factory floor. One example is using virtual reality to map out the best way for assembly-line robots to mount a driver's seat onto a car body.

Engineers styling a new model's interior or exterior can use a version of virtual reality called cave automatic virtual environment (CAVE) to produce a 360-degree view of a

EXHIBIT 1 | Digital Technologies Lead to Benefits at Multiple Stages for Automakers

	ENGINEERING	MANUFACTURING	AFTER SALES
VIRTUALIZATION	Uses simulation to reduce reliance on trial and error	Improves tooling and engineering	Automates exhaustive quality checks before launch
CONNECTED-CARS DATA	Reduces guesswork with empirical data, leading to less rework and more robust planning	Rightsizes specifications on the basis of actual data	Allows for fleet performance tracking and predictive diagnostics
COLLABORATION PLATFORMS	Increase agility, reduce rework, and improve knowledge sharing	Enable real-time updates and optimization of vehicle cost and weight	Make component validation more robust and traceable
ARTIFICIAL INTELLIGENCE	Automates design work and validation of product functions	Improves assembly validation processes	Improves tests that identify product failures, reducing warranty costs
	Improves R&D efficiency 3% to 5%[1] Cuts lead time by 3 to 6 months[1]	Reduces materials costs 2% to 3%	Reduces warranty costs 3% to 5%

Source: BCG analysis.
[1]At constant complexity, can be reinvested to absorb increased complexity.

physical environment. The virtual mockup lets engineers spot and flag design imperfections and then use the information to build 3D-printed models for further inspection.

Although virtualization technologies make simulations more accurate, the age-old problem of "garbage in, garbage out" still applies. If the underlying data is not accurate, even the best virtual models won't produce good results, and they could falsely predict how components will behave in real-world conditions. To ensure accuracy, engineers must follow structured and rigorous data-gathering processes, and develop tools to assess data quality. By ensuring the accuracy of data, they can create a self-perpetuating circle of trust: the more they trust simulation results, the more likely they are to use simulations in their work, and the more frequently simulations are used, the better the resulting data will be.

In addition, engineers may continue asking for physical prototypes because they are not aware that a digital simulation could fit their needs. Centralizing requests for both physical and digital prototypes could allow for proactively proposing a digital alternative to a physical prototype on the basis of criteria such as simulation predictability.

Data from Connected Cars. Automakers once determined things such as the size of the engine to include in a new model or where to position the steering wheel on the basis of past experience, technical guesses, and qualitative customer feedback. Today, OEMs can base such decisions on quantitative data from connected cars, which tells them how people actually drive, including which features they use and how they use them.

Today's car components, from the powertrain to side-view mirrors, generate signals and diagnostic information that an automaker's data scientists can analyze to right-size features and functions so that they deliver only what customers want and use. That limits the time and money carmakers spend on underused systems or functions, thereby improving a vehicle's quality-to-cost ratio.

One auto OEM that switched from designing power steering torque based on past experience and guesses to using connected-cars data expects to save 5% to 10% in power steering materials costs. The same automaker also used connected-cars data to identify close to a dozen additional use cases that cumulatively could save up to $50 per vehicle, a substantial amount considering the millions of cars the company produces a year.

Collaboration Platforms. Enterprise social networks and other types of collaboration platforms can reduce the volume of information stuck in email inboxes and spreadsheets, and replace meetings and memos as a more timely way to share updates. Dismantling barriers to effective communication is important when car companies have thousands of people in engineering departments around the world working on the same new model.

Teams can create channels on enterprise social networks to quickly broadcast problems to a large group, which can lead to better brainstorming and reduce the time it takes to find a solution. At one automaker, an engineering team struggled to optimize the sound in a new model's interior, a process called spatialization. Eliminating unwanted echoes and other bad acoustics requires input from teams designing the car's door, interior, and in-vehicle infotainment system, as well as from the vendors supplying the sound and amplifier systems. A temporary channel called #Spatialsound-issue was created on the company's enterprise social media platform to enable the teams involved to brainstorm and share progress on efforts to resolve the issue. Widespread collaboration on the channel helped the participants find a solution in two weeks, far faster than it would have taken if they had relied on meetings and other traditional problem-solving methods.

Collaboration tools can speed up product development by offering a faster way to share progress reports. Historically, creating progress reports on new models involved manually entering data, copying information from multiple systems, and then consolidating and reconciling the information. The process was so cumbersome it happened only twice a year. As a result, if work deviated from set targets between milestones, the news might not be communicated until months after the fact, which could delay implementing corrective measures and postpone production. By contrast, collaboration platforms and tools that streamline data collection let teams share data in real time, allowing them to correct course immediately and steer projects more effectively.

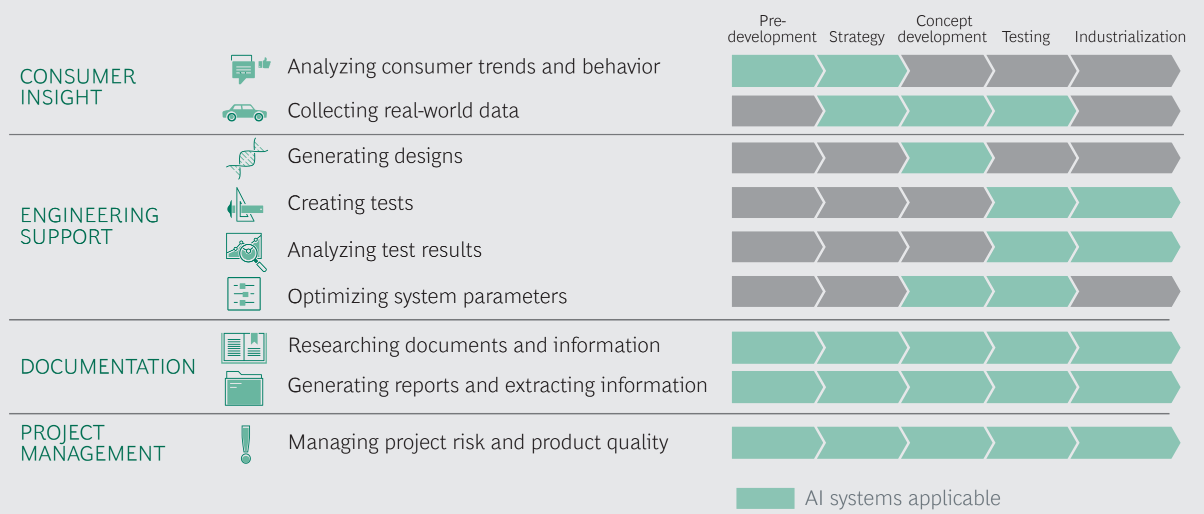
Engineers at one automaker used a real-time parts design platform during the design of a new low-cost model. The platform let them monitor daily the more than 3,000 parts in the prototype to keep close watch on factors such as weight and cost. Doing so helped the team prioritize features and design elements and optimize features-to-cost ratios. When the car debuted, the features it included at its relatively low price point made it so popular that the automaker had trouble keeping up with demand.

Collaboration platforms can also ensure that information remains up to date and consistent across the multiple applications used to build mockups of systems and subsystems. For example, if requirements shift for a high-level system, such as the car body, sharing the update through the collaboration platform can alert team members working on subsystems to the change. Collaboration platforms also can facilitate interactions between carmakers and third-party suppliers. Product life cycle management (PLM) software and data-quality verification tools can serve as effective collaboration platforms for making sure that data remains consistent from one phase of work to another.

Artificial Intelligence. AI has existed in various forms for decades, but as a result of new algorithms, cheaper processor power, and vast engineering data, modern AI can bring significant improvements to multiple engineering processes. AI's chief impact comes from training and deploying algorithms that "learn" from experience and then use the information to predict actions. AI-based natural language processing can be used to find information buried in engineering development project databases faster than other search methods. (See Exhibit 2.)

AI holds particular promise for improving automotive design. In the typical design process, OEMs define requirements for parts, components, and systems that tier-one suppliers create and perfect through multiple rounds of design work. OEMs also assemble and validate parts to make sure they work as intended. The process remains largely manual, involving substantial

Exhibit 2 | AI Can Be Used at Almost Every Stage of Automotive Engineering



Source: BCG analysis.

time and engineering personnel. Engineers can use AI-based algorithms to create design options from specifications and existing designs, freeing personnel to concentrate on other tasks. AI can also shorten design time and improve the attractiveness and quality of new models. A significant barrier to incorporating AI into design work, however, is ensuring that the required data is error-free and accurately labeled so functions such as machine learning can use it in the right context.

In the later phases of the engineering process, AI can reduce the time needed to test components, systems, and entire vehicles. For example, ADAS must go through several hundred million miles of simulations of real-life driving conditions to make sure it's reliable and meets regulatory standards before it can be added to a new model. Machine learning–based AI can create better driving simulations and analyze the results to identify irregularities that could signal a problem. In addition, many other types of tests, including tests of physical prototypes, continue to be done manually. AI reduces manual testing by automating test design, execution, and analysis. When it is used in testing, AI can cut prototype costs, the number of tests required, and their duration. By improving testing, AI also reduces the number of new cars with faulty parts.

For all its benefits, AI takes more effort to integrate into engineering than some more conventional analytics. Before adopting it, automakers should assess the benefits of AI against the effort required to use it so they can identify situations where it could significantly improve results.

Getting Started with Digital Technologies

On the basis of our experience working with car companies on the digital transformation journey, we recommend starting with a limited set of pilot projects on models in development. This allows management to ensure everyone is working toward the same goal in the same way and sufficient budget is allocated to the project, thus reducing change management risks.

Once the digital technologies tested in pilots are shown to be successful, they can be deployed in other new-vehicle development projects and can even be retrofitted for use in ongoing vehicle production. To launch a pilot, we suggest taking the following steps.

Identify pain points. Choose candidates for pilot projects by determining which problems in the vehicle development process are most pressing. Select a relevant use case as a jumping-off point on the basis of how much it could improve a process and how quickly the new technology could be implemented. Other considerations are how ready the project team is to spend time on the pilot and the immediate value the project can create. Typically, projects are selected because they're in a development phase relevant to the digital initiative—for example, launching a collaborative parts design database to handle initializing milestones for engineering bills of materials (BOMs).

Take a test-and-learn approach. If initial pilot projects are successful, use the information from them to address other pain points on the same vehicle prototype or on other new models in development. When enough evidence of success is developed through initial use cases, use it to launch a wider roll-out of the digital tools into regular production.

Create a digital innovation center. It's easier to scale up digital technologies if the effort is organized and managed through a hub large enough to attract and allocate talent. A digital innovation center should include people familiar with new technologies and processes such as agile coaches, software developers, user experience designers, data scientists, and data analysts. (See *Digital Transformation from the People Perspective,* BCG interview, January 2018.) Talent could be collocated with engineering departments to spearhead the transformation by implementing best practices. Digital innovation center personnel can also take what they learn from one project with them when they start a new one.

Automotive manufacturers face multiple road blocks. Research and development, testing, and other engineering practices are becoming more complicated at the same time as tech-savvy competitors are entering the field, regulation is increasing, and autonomous-vehicle technology is moving from drawing boards to highways. One of the most promising options for dealing with these changes is digitizing engineering methods, using everything from virtualization to AI. But OEMs cannot simply hit the gas on such efforts for fear of being left behind. They can increase their success rate by identifying where new technologies would have the most impact on cost and productivity. Legacy automakers' years of experience give them an advantage over younger rivals. By integrating digitization into already hard-earned mechanical and manufacturing process know-how, they could ultimately lap the competition.

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