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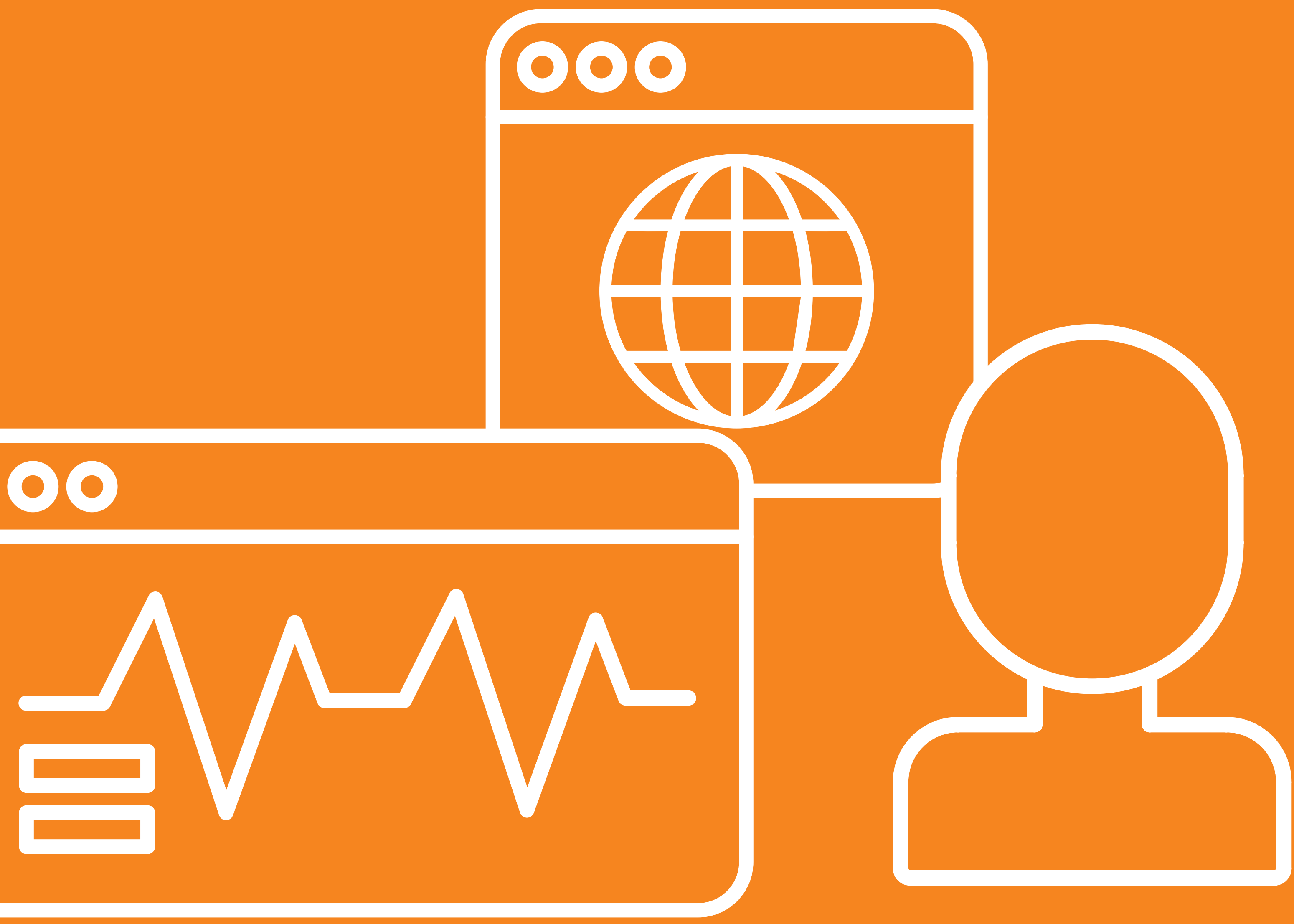
To cope with rising product complexity and crushing amounts of data, teams must embrace the cloud to maintain a competitive edge.

Optimizing the engineering life cycle requires digital transformation



Today's engineers are facing a dramatic shift happening in industries like automotive, aerospace, and electronics. Competitive pressures to bring products to market faster, slash development costs, maintain quality standards, and out-engineer and out-innovate competitors are forcing companies to fundamentally change the way engineering teams work. Customer and market demands are driving the need for companies to overhaul their old methods for newer, more agile processes that optimize the entire engineering life cycle. This paper explores these challenges and dives into real-world scenarios of industry leaders who are successfully and positively disrupting the market.

When he slid into the IT driver's seat as CIO of Visteon in 2017, Raman Mehta's challenge was to transform IT for the traditionally hardware-centric supplier of automotive cockpits. The company was shifting to a software-based innovator that delivers infotainment and "smart" dashboard display systems for connected, electric, and self-driving vehicles.

At the time, Visteon's 4,000 engineers, located from Chihuahua, Mexico, to Shanghai, China, were using traditional spreadsheets and homegrown systems that didn't talk to each other. In the automotive industry, products often tend to have the same basic design, with slight variations for different models or trims. This creates a golden opportunity for reuse, but Visteon's teams were using multiple spreadsheets for the same design and essentially duplicating efforts.

"We were losing productivity," says Mehta. "We needed a new mindset, a new culture, and a different way of innovating. We wanted to have our engineers focused on engineering and creative tasks, not worried about managing the underlying infrastructure."

Mehta's team beefed up the company's wide area network, built a cloud infrastructure, and set about capturing all engineering data, converting it into a neutral format and building one platform with common application programming interfaces across all engineering teams. Today, when Visteon engineers are managing requirements or test cases,

Key takeaways

- The complexity of today's software and products, combined with rising customer expectations, is forcing engineering teams to change the way they work.
- Teams must use new technologies and agile processes to optimize the engineering life cycle and continuously improve product development.
- Companies that aren't investing heavily in new tools and processes and transitioning to digital engineering are already falling behind.

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>
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everyone works off the same data. Executives have visibility into the entire engineering life cycle and can identify and manage projects early on that are in danger of running over budget, falling behind schedule, or that might require additional resources.

The company is already seeing benefits. Visteon has been able to keep abreast of a changing product landscape that has more software components in the bill of materials. Products now have a lifespan of two-to-three years, as opposed to five-to-six years in the past. The overall quality of code, so critical in an industry where safety and security are paramount, has improved. Collaboration among teams has helped generate innovation and digital-native thinking. And Visteon has been able to "derive maximum benefit from the software skill set we have in our engineers," says Mehta.

In today's environment, where agile newcomers are disrupting entire industries, incumbents must transform the way they work and tap into new technologies to

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Jesper Christensen, Director of Offering Management, IBM Watson Internet of Things

The products Visteon manufactures today have a lifespan of two-to-three years, as opposed to five-to-six years in the past.

survive. "If you don't know how to take advantage and be on the forefront, you're going to fall behind your competitors," says Jesper Christensen, director of offering management for IBM Watson Internet of Things. "You can't keep doing development the same way you have for the last 10-to-15 years."

New demands, new responses

Leading-edge companies are responding to these new realities by transitioning from manual processes to digital systems that provide teams across different functions and geographies with a common tool set, a collaboration system, and cloud-based access to shared real-time data.

And digital engineering data is being connected to the rest of the product development lifecycle, creating a digital thread that stretches from product conception through design, manufacturing, and customer feedback, providing end-to-end engineering life cycle management. This intersection of cloud-based integrations hasn't been possible until today, with major advancements in engineering systems.

Organizations are plugging into technologies like the internet of things (IoT) and artificial intelligence (AI)-based data analysis to understand how products are actually being used by customers, and to adjust product development accordingly, in a cycle of continuous improvement. AI is being deployed in a variety of ways, from expert systems that help junior engineers write better requirements to machine learning that analyzes large data sets in order to spot patterns and help optimize processes. Companies that don't make this transition run the risk of getting shut out of the market.

At Visteon, Mehta's goal is to create a "seamless journey from product engineering to production engineering and compress concept-to-cash cycles," which includes the increased reliance on digital simulations to help optimize form factors and manufacturing workflows. With a product life cycle management system that is open and connected, Visteon is aiming to gain a competitive edge by establishing a tighter working relationship with original equipment manufacturers, driving down costs and improving product quality. And the company is "betting big on AI," both in terms of putting more intelligence into the cockpit electronics products that Visteon engineers have designed and in the deployment of AI data analytics during the engineering process to "deliver high-quality software at lower cost in a very compressed time frame."

Challenges facing engineering teams

Integrating and optimizing the way engineering teams function has become even more critical as the complexity of products increases. Case in point—today's cars have about 30,000 parts and more than 100 million lines of code.

And the emphasis has shifted from hardware to software-intensive advancements such as autonomous capabilities. For example, the braking apparatus on a car now has a collision-avoidance feature that combines sensors and cameras with real-time data analytics to send audio and visual alerts to the driver. If there is no response, the system can execute an intelligent, independent decision to apply the brakes and avoid a crash.

Visteon engineers are creating domain controllers that aggregate all of that sensor data and convert it into dashboard displays that feature touch screens, voice activation, and even a "heads-up" display that projects information onto the windshield.

"Making sure that everyone is on the same page is a key challenge for engineering teams," adds Pierce Owen, principal analyst at ABI Research. "Companies are responding with cloud-based collaborative platforms so all engineers are looking at the same data and changes are communicated to everyone in real time."

At defense contractor Raytheon, all engineering work was done in isolation until just a few years ago, says Chris Finlay, senior principal systems engineer. "Even if we were developing models, they were stovepiped and not connected to other models," he said. "You could be writing requirements in one system and have no way to link the hardware design to those requirements digitally because they're in a

Drivers of complexity

The jobs of engineering teams today have become increasingly complicated by an assortment of factors:

Software: Intricate systems such as a collision-avoidance feature in cars, for example, combine sensors and real-time analytics.

Products: An engineering error made early in development could trigger product recalls or even cost lives.

Personalized experiences: Customers want to buy products and services they can customize to their individual needs and preferences.

Cross-system dependencies: Engineering teams that use spread-sheets and systems that don't talk to each other risk duplicating efforts.

Internet of things: Data is constantly flowing through IoT systems to development processes to improve products and services.

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Chris Finlay, Senior Principal Systems Engineer, Raytheon

CAD system that doesn't talk to the requirements management system."

Finlay leads a team that has been working to replace document-based information exchange with a digital platform for engineering teams designed to eliminate gaps between different tool sets and stages of the design process. "Once you start to capture things digitally you can start to exploit machine learning or AI algorithms. You can start to reduce development costs because you can automate tasks that you were doing by hand," says Finlay. The platform requires standard programming languages, so Finlay's team was able to eliminate peer review gaps, duplicate data, and the cost of doing rework.

Engineering teams in manufacturing also face challenges not found in IT-based industries. For example, a software error in a new productivity app might just mean a business process doesn't work as expected. Engineers developing physical products, on the other hand, understand that a mistake could cost lives or result in product recalls. And engineers in defense, automotive, and aerospace industries operate in a regulatory environment that requires careful safety and quality testing, documentation, provability, and traceability of data.

Rising customer expectations

Another challenge facing manufacturers is customers expect continuous improvement and innovation. Customers today not only want their manufactured products to be high-quality and low-cost, they want to be able to customize products to meet their individual needs and preferences. "Our customers are continuously challenging us to push the technology envelope," says Finlay. "The customer wants it faster, better, cheaper, and sometimes the customer wants it yesterday."

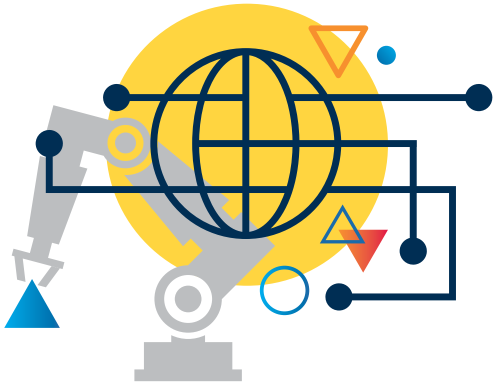
Henry Ford famously said, "Any customer can have a car painted any color that he wants so long as it is black." That worked in 1909, when supply for the new product was limited, but today, consumers want to go online and build their dream car with specific features and functionality, down to the smallest detail. That's an unprecedented level of complexity that engineers need to take into account when designing products.

And whether it's an automobile, an elevator, a washing machine, or a missile defense system, customers are also beginning to expect real-time diagnostics based on embedded IoT sensors, high-speed cloud connectivity, and AI-based analytics. After all, if a car is continuously collecting usage data and sending it back to the manufacturer, why should an owner have to wait for a regularly scheduled maintenance check to be notified that a certain part or system needs attention? And wouldn't the collision avoidance system be even more effective if it were connected to real-time weather and traffic conditions?

At Raytheon, Finlay's goal is to have IoT sensors send data back from systems in the field so the company can perform predictive maintenance. Using AI systems to analyze vast amounts of IoT data can provide deeper insight into how systems are performing, which can feed back into design. Depending on the information, the company can go back and beef up an area that needs it, or, conversely, identify where a certain component might far exceed requirements, allowing a cost-saving switch to a less expensive but equally functional alternative, says Finlay.

Destination: Continuity

Transitioning from an engineering organization that builds electromechanical devices to one that integrates software into the product design process



> "In the engineering process, you define what you want to do, design it, build it, test it, and prove that you've done it. The key is integrating those steps."
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> Joe Schmid, Director of Worldwide Sales, IBM Watson Internet of Things

is a difficult leap for many companies, according to Sky Matthews, CTO, Internet of Things, at IBM. "Changing to a software-driven practice is a cultural shift at every level of the company. It's a big mindset shift that has to be carefully done," Matthews says.

As with any undertaking of this magnitude, the prudent approach is to pick a pressing pain point on which to focus. Companies should identify a specific bottleneck and address it with a small, multidisciplinary team that uses agile development methods to achieve quick results. First successes lead to others, enabling engineering teams to win broad support across the company and to incrementally scale their efforts. The key is to make sure to automate processes along the way. At the same time, pinpointing one project to start with doesn't mean taking a piecemeal approach. Companies also should have a larger, strategic plan for creating end-to-end transformation of the entire development life cycle—not just technology, but also people and processes. The process entails assessing their digital readiness, identifying steps that need to be taken, and then prioritizing actions based on business requirements.

At the most basic level, accelerating product development cycles—the shift from building a new car model every five years to continuous improvement and continuous delivery—is a huge cultural change. Mechanical, electrical, and systems engineering teams that have been operating in their own siloes with their own tool sets and procedures now have to collaborate with millennial software engineers in one integrated product development team, working together on a common platform.

"One of the biggest challenges is the culture shift, getting people to embrace this new digital engineering approach," adds Finlay. "Whether you're right out of college or close to retirement, there's a whole training aspect involved with new technologies and a new way of doing things. Senior engineers need to be trained in a new way, and there's a lot of inertia to overcome." This is where AI comes in—to help translate legacy expertise for junior engineers, and likewise leverage new intelligence to inform age-old processes.

'System of systems'

The transformation of engineering teams requires digital tools that are integrated across the entire engineering life cycle. It's also important to install workflow management systems that enable the entire process to be monitored through a dashboard and verify that all the proper steps are followed in the right sequence and that deadlines are being met.

Data flows should be standardized, as companies build one system of record. "In the engineering process, you define what you want to do, design it, build it, test it, and prove that you've done it. The key is integrating those steps," says Joe Schmid, director of worldwide sales for IBM Watson Internet of Things.

But integrating is hard. Schmid said customers he's worked with are often good at one part of the process, such as design, but they don't integrate design into the life cycle. "When they need to change goals or specs, it's all in people's heads," he said. "That doesn't work anymore with the complex systems we have today. One engineer can't have an entire system in their head. That's when errors pop up."

The goal is to create an integrated "system of systems," a closed loop that runs from the requirements phase of product development to real-time monitoring of how consumers are using the product, then deploy AI systems to analyze the data and leverage that knowledge to improve the product, says Dibbe Edwards, vice president of IBM Watson IoT Connected Products Offerings.

One of the key benefits of going digital is the ability to reuse components. "As model libraries get built up, the ability to reuse parts is exponential," says Finlay. "That's where we're seeing the biggest return on investment in the whole model-based engineering world." Imagine receiving an order from a customer to design a new product and having 80 percent of the design work done because components are already in the library.

Digital modeling systems can also perform millions of simulations and test runs. Finlay explains that when developing a weapons system, Raytheon engineers might create a model and perform a simulation to determine how the design holds up under extreme structural pressure. Then they would run a separate simulation for extreme heat or cold. With new digital modeling tools, engineers can combine those simulations, run multiple iterations, and complete a task in a matter of weeks as opposed to months, Finlay says.

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of failed projects are due to poor requirements.

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of rework that needs to be done are due to requirement errors.

Source: Project Management Institute

Another benefit is being able to link engineering models to the manufacturing process. "It all ties together," says Finlay. Eventually, the goal is to automate test procedures, to have the system analyze whether a certain part passed or failed a test, make the correction, retest, and then have the software autogenerate the lines of code required by the manufacturing software systems.

And the move to a digital platform will enable engineering teams to adopt entirely new ways of working, ABI Research's Owen says. For example, there's a new technology called generative design, in which engineers essentially describe the requirements of the product and the software generates hundreds of designs from which the engineer can choose. Generative design has the potential to make engineers more productive, speed the development of final designs, and ultimately lead to higher-performing parts, Owen says.

Putting it all together with AI and IoT

AI can play a key role in industries across the entire product development life cycle. To start with, AI can enable companies to extract business insight from the vast trove of historical data that has already been collected and is not providing the value that it could. "There are terabytes of engineering data inside customer organizations," says Schmid. "How can customers take advantage of that data? How can they leverage AI to build better products as they go forward?"

Owen adds that with AI systems, companies have the opportunity to not only accumulate and analyze customer data but also harness workforce data, allowing the company to bridge the generations and use AI systems to help train the next wave of engineers.

Companies can also improve the requirements process by deploying AI-based expert systems that help individual engineers to write better requirements—a key advantage, as poor requirements are a critical factor in project failure. According to a report from the Project Management Institute, 47 percent of failed projects are due to poor requirements, and requirement errors are responsible for 80 percent of the costly rework that needs to be performed, as well as 50 percent of project defects.

Cloud-based AI systems can analyze requirements in real time as the engineer is writing them, which is especially helpful for younger engineers who lack the experience and institutional knowledge of their more experienced counterparts. By encoding standards and best practices, AI systems can automate lower-level processes, freeing up engineers to innovate.

This same type of AI-backed process optimization can be extended to modeling, quality assurance, and testing, which can then be integrated into one system. At Visteon, Mehta wants to use AI to analyze engineering processes as they are being rolled out, so that the system can analyze the maturity of requirements, spot trends, and identify programs that might be at risk.

Innovative companies like Whirlpool are already moving down that path. Whirlpool is currently equipping its washers, dryers, dishwashers, and ovens with IoT sensor systems that connect to cloud-based analytics, providing a two-way flow of information between Whirlpool and its customers. Whirlpool engineers benefit from being able to have a deeper understanding of how customers are using the machines, which is invaluable for product development. And customers get alerts if the sensors detect a problem.

And IoT projects have a solid return on investment, according to Matthew Wopata, an analyst at market research firm IoT Analytics. A recent survey by the company found that 17 percent of respondents amortized their IoT project costs in less than six months, and another 40 percent said they achieved ROI in less than a year.

The new generation of industry disrupters are, by definition, digital-native and cloud-based, making them nimbler and faster than companies with legacy infrastructure and old-school engineering processes. The good news is that the disrupters are building a blueprint with clear actions to help engineering teams commit to the mindset shift toward enterprise-scale transformation.

A transformation checklist

Engineering teams today are adopting cloud tools and modern methodologies to streamline their processes and move at lightning speed. Here's a checklist for engineers as they make the transition.

1. Adopt agile methods and practices.
2. Optimize across the end-to-end engineering life cycle.
3. Apply advanced analytics and AI.
4. Actively shape industry standards for compliance.
5. Engage early across the supply chain.

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