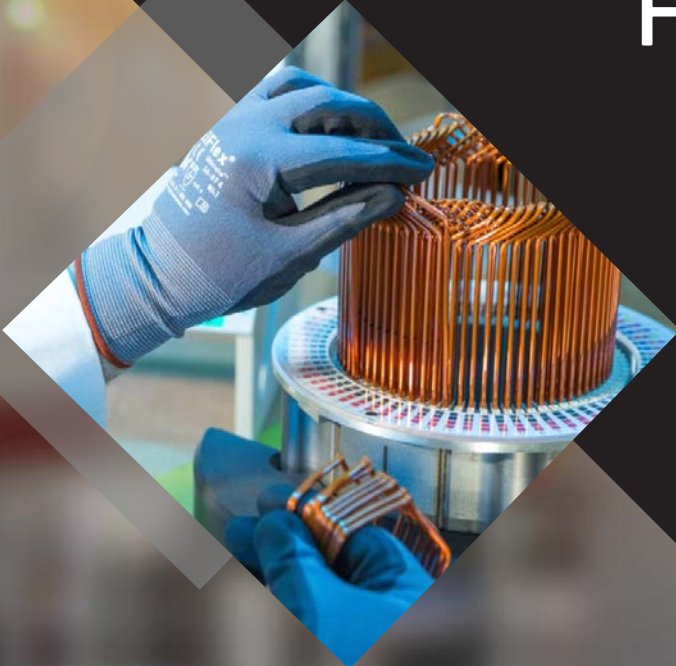




xPRO

# GM: THE PATH TO AN ELECTRIC FUTURE



## GM: THE PATH TO AN ELECTRIC FUTURE

In 2017, General Motors (GM) announced that the largest US vehicle manufacturer was all-in on electric and autonomous vehicles for its future fleet. “General Motors believes the future is all-electric,” said Mark Reuss, then the company’s global head of product development<sup>1</sup>. “We are far along in our plan to lead the way to that future world.”

GM, of course, is not new to electric cars. Its hybrid electric Volt, one of the first mass produced electric vehicles, was well-received following its 2010 debut. Although hybrids are in the rear view for GM—the company ceased production of the Volt in 2019—they paved the way for the company’s all-electric Bolt EV hatchback introduced in late 2016. The Bolt EV will remain a staple of GM’s product line with an updated Bolt EV and new Bolt electric utility vehicle coming soon. In addition, GM entered the autonomous vehicle market segment in March 2016 with its majority-owned Cruise division, currently focusing on shared ridership through electric vehicles.

GM is investing heavily in its electric vehicle strategy with the promise of \$20 billion through 2025 to engineer<sup>2</sup> and build out its menu.

## MODULAR PLATFORM POWERED BY ULTIUM BATTERY

In March 2020, GM CEO Mary Barra revealed specifics of its future electric vehicle strategy based on the Ultium battery and a modular flexible drivetrain architecture. “Our team accepted the challenge to transform product development at GM and position our company for an all-electric future,” she said. “What we have done is build a multi-brand, multi-segment EV strategy with economies of scale that rival our full-size truck business with much less complexity and even more flexibility.”<sup>3</sup>

Going forward, GM plans to manufacture 19 different battery and drive unit configurations compared with 550 internal combustion powertrain combinations available today.<sup>4</sup>

GM is currently spending \$2.2 billion to overhaul its Detroit Hamtramck facility to manufacture autonomous and electric vehicles. By 2023, GM plans to release 20 electric vehicles across all four of its GM brands and Cruise, showing that GM is intent on electric deployment across market segments, rather than defining electric as a market niche.<sup>5</sup>

These are ambitious goals. GM has made a concerted effort to implement systems engineering within the organization to achieve these goals. Soon after Barra assumed the CEO job in 2014, she embarked on a cultural change within GM, including creation of a product integrity team, ensuring that quality, safety, and design considerations were better governed in decision-making. “We have restructured our safety decision-making process,” said Barra. “Our responsibility is to set a new norm and a new industry standard on safety and quality.”<sup>6</sup>

The change followed a serious ignition switch issue culminating in 2014, but it simultaneously laid the groundwork for resetting the company’s compass toward electric and autonomous vehicles. At the root of the change: a systems engineering focus and a commitment to educating GM employees about its implementation across the organization. One of the first steps GM took was to ramp up employee training regarding systems engineering. As part of that effort, MIT xPRO’s [Architecture and Systems Engineering: Models and Methods to Manage Complex Systems](#) online certificate program was brought into the mix in September 2016. Since then, 185 individuals within GM globally have completed the four-course program.

## PART OF A BROAD SYSTEMS ENGINEERING MENU

When GM made a full-on push for systems engineering practices, Richard Kewley, then the executive director of fuel systems and chassis advanced development at GM, conveyed the company's intent that systems engineering is a method requiring full participation from everyone in the organization. Further, robust methods for traceability must be adopted. With design interactions across parts ranging from thousands to billions, a tool-based methodology for engineering was required.

Kewley urged the move from being document-based to across-enterprise linked-data tool sets – a core principle of model-based systems engineering (MBSE). And, he emphasized the need to lead the business to MBSE.

As part of that enterprise-wide mission, GM partnered with MIT xPRO to launch an online program in systems engineering, focusing on MBSE in 2016. In parallel, GM established a curriculum for a system engineering degree program in 2016 for its qualified engineers that required 3.5 years of study.

“While the 3.5 year program was ideal for more junior employees eager to receive a Master's degree, it was not suitable for those farther along in their careers, many of whom already had two or three graduate degrees, including several PhDs,” explains Padma Sundaram, now Chief Architect, Autonomous Vehicles, Safety and Systems Engineering at GM. She was part of the team that co-founded the systems engineering Master's degree course.

Ms. Sundaram recalls they could not hire enough systems engineers or people experienced with a systems engineering or architecting mind set. “We needed to develop this competency and expertise in-house and educate people in-house,” she says. “We want to have a continuous pipeline of engineers with this skill set.”

GM was part of the founding group of approximately ten major companies and organizations, including Boeing, Applied Materials, GE, and Raytheon, to offer the MIT xPRO certificate program to its employees. Its goal was to help career professionals learn the latest cases on systems engineering and, most importantly, apply systems thinking almost immediately through the MIT xPRO certificate course.

To date managers, architects, senior project engineers, controls engineers, design release engineers, among others have enrolled, spanning GM sites across Canada, Brazil, Italy, Mexico, and India.

“Because MIT is curating the content there is an expectation that there will always be fresh or up to date and topical,” says Robert Wirthlin, a former GM employee who took the course when he was at GM. “Because MIT is also administering the content, there is an expectation that MIT is applying the latest in adult learning in terms of being able to reinforce the way adult learners think so that they retain concepts taught.”



## “HELPED ME TAKE THE BLINDERS OFF”

William Villaire was in the inaugural MIT xPRO class of 12 GM participants shortly after moving into the fuel systems group. His focus was on delivery of fuel from the tank up to the engine. “That program helped me understand some of the available tools to apply systems engineering, to really get a different mindset, take the blinders off and understand where the stakeholders are and how to decompose the system and create an architecture of the system,” he recalls. “It really helped to see how that rolls down throughout the subsystem and components that make up that system.”

He especially recalls how the program gave him usable tools, such as the design structure matrix and system decomposition, to better develop a system-level framework and understand all the inputs from the various subsystems and how they interconnect.

“It was taking what was offered in the classes and being able to apply it,” Villaire says, who now works in chassis fuels. “A lot of classes you take, you can’t always apply what you learn. But I was able to apply a lot of what I learned. Even as I’ve moved into different areas since then, I still have that system-level mindset not just looking into what our group is doing.”

He recalls an example shortly after completing the coursework regarding an issue with thermal management of fuel delivery. “When the issue was identified, we were able to come together as stakeholders, not just the chassis team, but also powertrain, calibration team, and we developed a decent model that incorporated the entire system after we identified all the key players to tackle an issue before it became a problem out in the world,” he says.

## LEARNING FROM OTHER INDUSTRIES

“I really enjoyed the industry experience—how the instructors discussed what systems engineering is and how it is implemented at different companies,” says Joshua Caffee, GM Systems Integration Engineer, who took the MIT xPRO program in late 2018, about 18 months after taking a system integration role at GM. “It gave me a sense of how to use it.”

What has stayed with Caffee in the time since he completed the program and moved to another systems role within GM is the emphasis on integrating everything well. “From the point of defining the architecture, setting the scope, writing and linking requirements,” he says. “It was very good background on what the reasoning was behind that and different ways to accomplish it.”



## SYSTEMS ENGINEERING EDUCATION OPENED DOORS

GM'S redirection towards electric and autonomous vehicles coincided with making the MIT xPRO systems engineering certificate available to its employees. For Nicole Bickley, the timing was particularly on-target as she transitioned to the company's Systems Engineering group.

"Even though I was working in systems engineering as a systems engineering program manager in 2016, I was early in my systems engineering development," she says. "By going through the four modules of the MIT program I got an understanding of what systems engineering is, how to apply systems thinking, and moving forward understanding how I can influence certain decisions and take on challenges and come up with creative solutions to resolve those problems that we see in our everyday work."

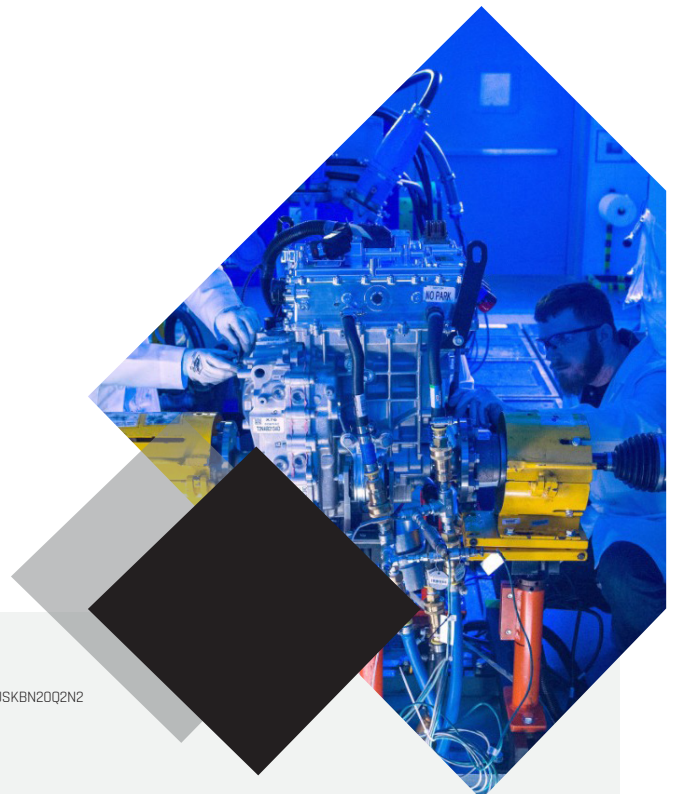
That experience led her to advance to a liaison role within GM supporting Electric Vehicles. In that position she represents her team charged with designing, releasing, executing electrical components on a vehicle. "In my specific program, we are working on battery electric vehicles where there are a lot of unknowns and uncharted territory that we haven't experienced - so we are learning as we go to make the best decisions based on information we have in support of our future developments," she says. "It's imperative we are sharing as much as we know and be sure that we are operating from the same list of assumptions, getting

good ideas from across the functions, and not just focusing on the components that we are responsible for releasing."

A year after Mark Reuss announced the all-electric future for GM, in late 2018 he told GM employees that big changes were on the horizon. Along with his rise to GM President in early 2019, the changes would mean aggressive restructuring the GM workforce and manufacturing capabilities globally.

In that message, Reuss stressed that the company had to become more virtual in the design and development of its vehicles; to build vehicles virtually down to the smallest components and work out any issues before a physical prototype is built.

The message was intended to prepare the company for the expansive changes, particularly that GM would need to adapt with global changes in vehicle demand; not just to keep up but to become a leader in the automotive industry regarding systems engineering.<sup>7</sup>



<sup>1</sup><https://www.wired.com/story/general-motors-electric-cars-plan-gm/>

<sup>2</sup><https://www.reuters.com/article/us-gm-electric/gm-takes-aim-at-tesla-with-ultium-batteries-and-fleet-of-electric-vehicles-idUSKBN20Q2N2>

<sup>3</sup><https://media.gm.com/media/us/en/gm/home.detail.html/content/Pages/news/us/en/2020/mar/0304-ev.html>

<sup>4</sup><https://media.gm.com/media/us/en/gm/home.detail.html/content/Pages/news/us/en/2020/mar/0304-ev.html>

<sup>5</sup><https://www.theverge.com/2020/1/27/21083356/gm-cruise-ev-av-production-announcement-detroit-hamtramck-origin>

<sup>6</sup><https://www.c-span.org/video/?c4501211/user-clip-opening-statements>. (See MB comments at 0:26 minutes of the video)

<sup>7</sup>These were comments provided to me in an interview with Robert Wirthlin in late 2018 when Wirthlin was at GM