LIFECYCLE INSIGHTS

THE ROLES OF SIMULATION AND TESTING IN PRODUCT DEVELOPMENT

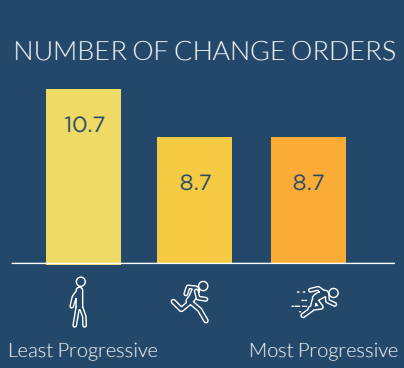
Findings from Lifecycle Insights' Return on Investment of Digital Transformation Study

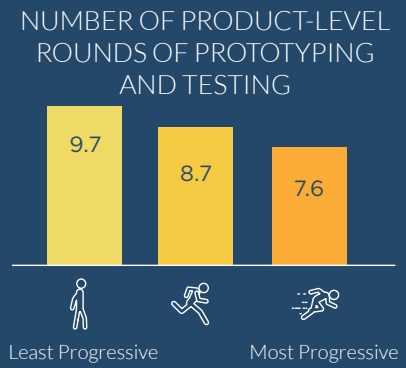
RESULTS OF THE ROI OF DX STUDY

Lifecycle Insights deployed its 2021 Return on Investment (ROI) of Digital Transformation (DX) Study to quantify issues driving manufacturers to pursue DX initiatives, measure product and development complexity, and examine the ROI of these efforts.

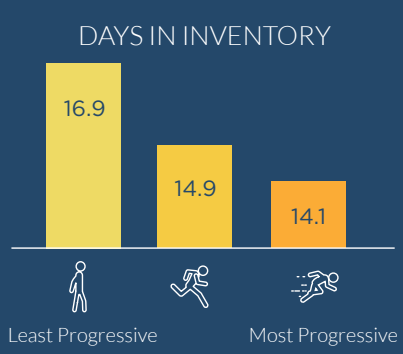
Simulation and test is a vital step in the product development process. The value extends from design all the way to product maintenance and servicing. It helps organizations build better products, enhance their safety profiles, and bring them to market faster. These improvements in the product lead to greater customer satisfaction. Findings from the ROI of DX Study demonstrate that companies that employ simulation need fewer prototypes, fewer engineering change orders (ECOs), and fewer days in inventory.

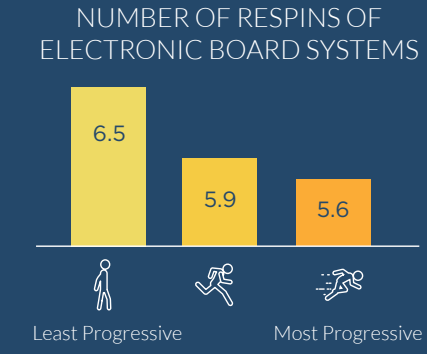
This eBook highlights the role of simulation and test in streamlining product development and manufacturing processes. Each section will explore the ROI of these efforts by comparing the most progressive and least progressive companies against critical business parameters.





Findings from Lifecycle Insights' 2021 ROI of DX Study show that most prototyping companies execute fewer change orders and rounds of protyping and testing.





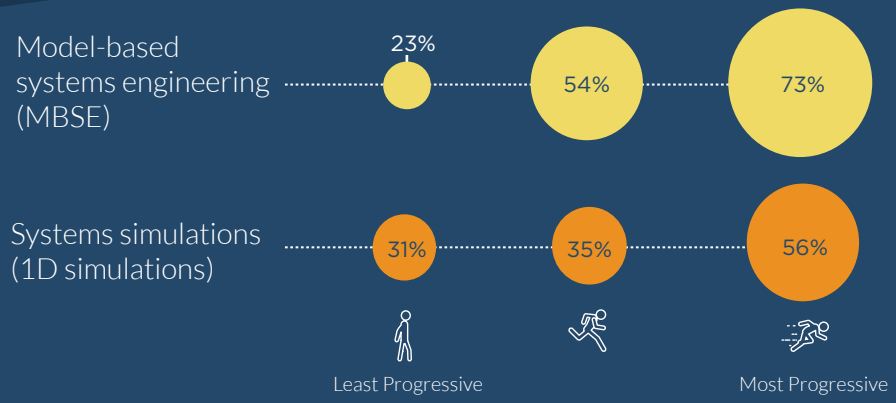
LIFECYCLE INSIGHTS

DEVELOPING SYSTEM ARCHITECTURES AND CONCEPTS

Today's products are composed of electronics, electrical systems, and software. As a result, there are more and more design requirements that span multiple engineering domains. As the complexity grows, defining product requirements, running trade studies on system performance, and ensuring functional integrity become more and more challenging.

Many companies are now using model-based systems engineering (MBSE), a top-down approach to product development that integrates product definition, requirement analysis, use case analysis, and functional analysis. Companies also employ 1D system simulation and generative design to create and validate novel system architectures that are nearly impossible to fathom through traditional design methods. The 2021 ROI of DX Study showed that DX initiatives such as MBSE and 1D system models helped the most progressive companies realize a minimum of 20% reduction in the number of prototypes over their peers.

Building system models, however, is not enough to guarantee success. Data access, integrity, and management are vital to the systems engineering approach when the model serves as the single source of truth. All of the definitions related to the product, including simulations, must be connected to the systems model, providing context and relationships. Further, this connected data must be available to all stakeholders throughout the product life cycle.



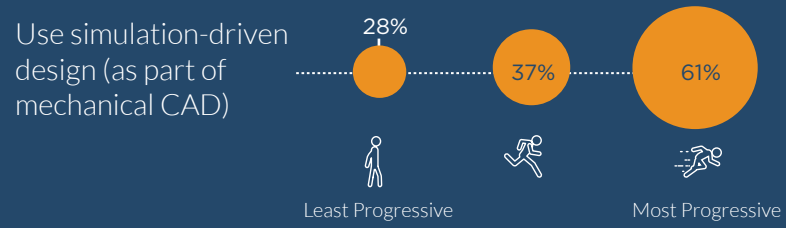
Findings from the ROI of DX Study show that the most progressive utilize MBSE and 1D systems simulations at higher rates than the least progressive.

EMPLOYING SIMULATION IN PRODUCT DESIGN

Simulation provides key insights to help engineers make better design decisions. Complex products require multiple physics to capture their behavior. Electronics are critical components of today's more complex products, which means engineers may need to perform electromagnetics, thermal, and drop tests, as well as traditional structural simulation, to validate their designs.

Traditionally, analysts (computer-aided engineering [CAE] specialists who are simulation experts) run simulations after designs are prepared. This means issues are often found late in the design process. Simulation-driven product design, however, allows designers to explore a plethora of different design candidates from day one. Engineers use generative design to create multiple innovative designs—something that is inconceivable using traditional design approaches—within a short time. Simulations can work with template-based automation and optimization components to form the foundation for generative design. So it's no surprise the 2021 ROI of DX Study found that respondents from the most progressive companies harnessed simulation-driven design to realize a reduction in prototypes and ECOs.

Simulation can create a lot of data, so it's important to have simulation data management to track design iterations. Then companies can make simulation data available to other departments and outside stakeholders to collaborate on design strategies and decisions.



Findings from the ROI of DX Study show that the most progressive use simulation in the design process at higher rates than the least progressive.

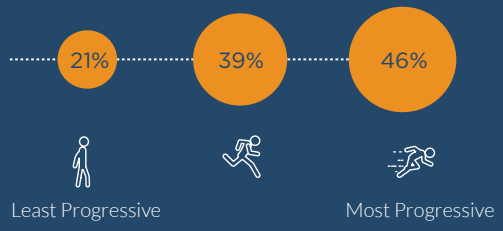
SHIFTING LEFT WITH ELECTRONICS SIMULATION

Demand for smart, connected products is rising. These products require more sensors, more software control systems, and more connectivity with internet-of-things features. This has caused the proliferation of increasingly complicated electronics multi-board systems. Engineers need to verify and validate the integration and performance of these electronics systems, which increases the risk of delays in the product development process. And instead of getting longer, today's schedules are getting shorter. In order to mitigate these issues and risks, companies are resorting to a shift-left electronics simulation strategy.

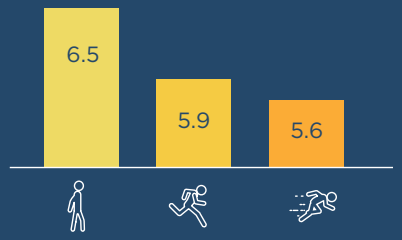
A simulation-powered shift-left approach allows engineers to verify and validate performance and behavior digitally instead of relying on physical tests. They can perform first-order simulations to check signal and power integrity and thermal characteristics, and to assess electromagnetic interference issues during design. They are far less constrained at this stage, so they can explore alternative approaches more freely. These simulations also let them verify that requirements are met far earlier. Digitally verifying requirements fulfillment through all design abstractions, from board layouts to system definitions, is extremely effective in reducing the number of physical respins during development.

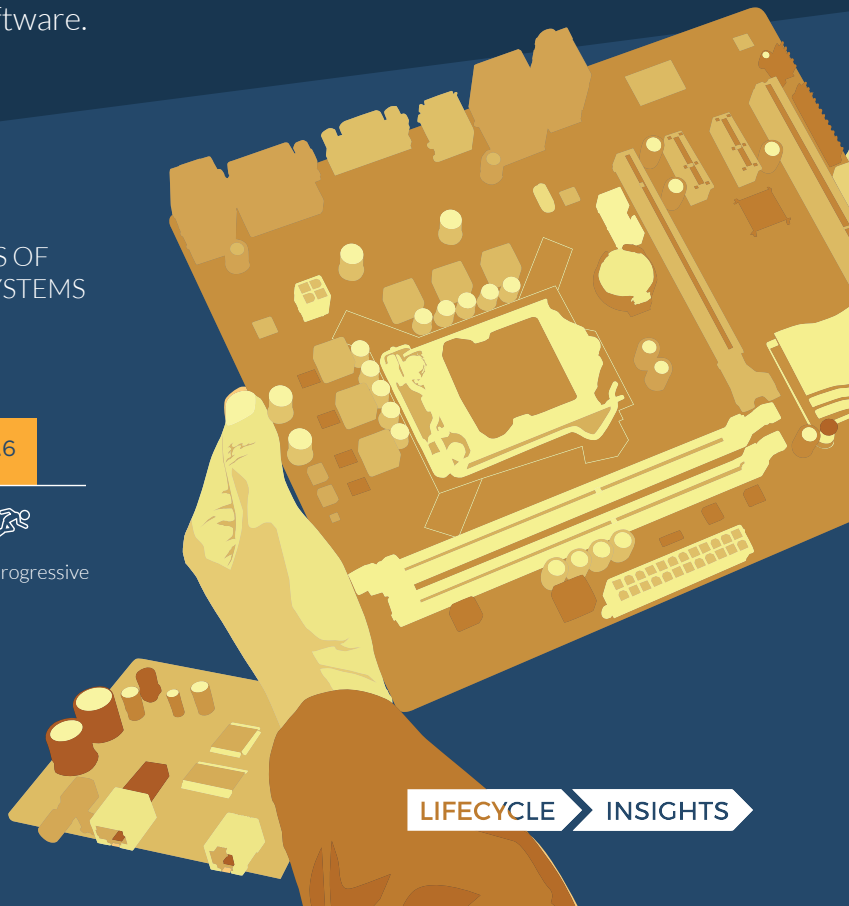
Electronic simulation creates a large amount of data. Each simulation has a corresponding electronic design model, a simplified simulation model, simulation options, and results. That adds up to a lot of files, and the number grows quickly as engineers explore many design variants. Companies track and manage all this data using the data management system. As stakeholders cycle through different design configurations, they can easily access all simulation data. Further, they can view simulation results without installing specialized software.

Early electronics simulation and validation (as part of electrical CAD)



NUMBER OF RESPINS OF ELECTRONIC BOARD SYSTEMS





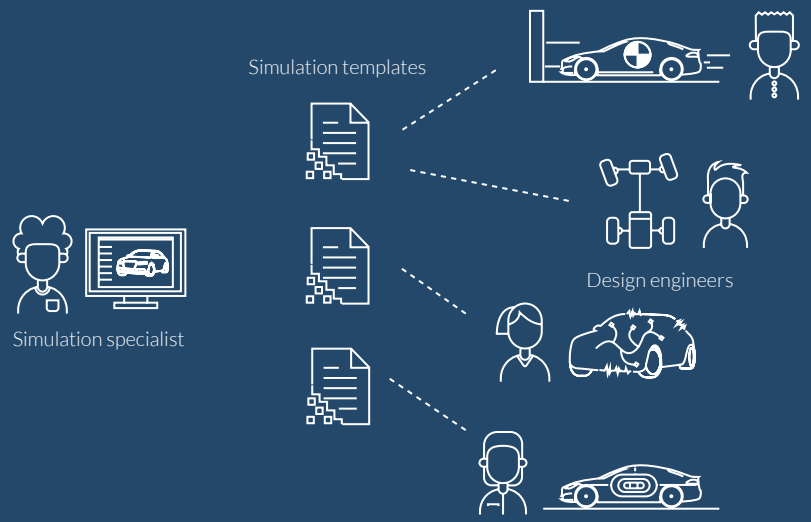
Findings from the ROI of DX Study show that the most progressive companies use more electronic simulation and validation early in the design cycle and conduct fewer respins of their electronic board systems.

BUILDING CONFIDENCE IN USING SIMULATION

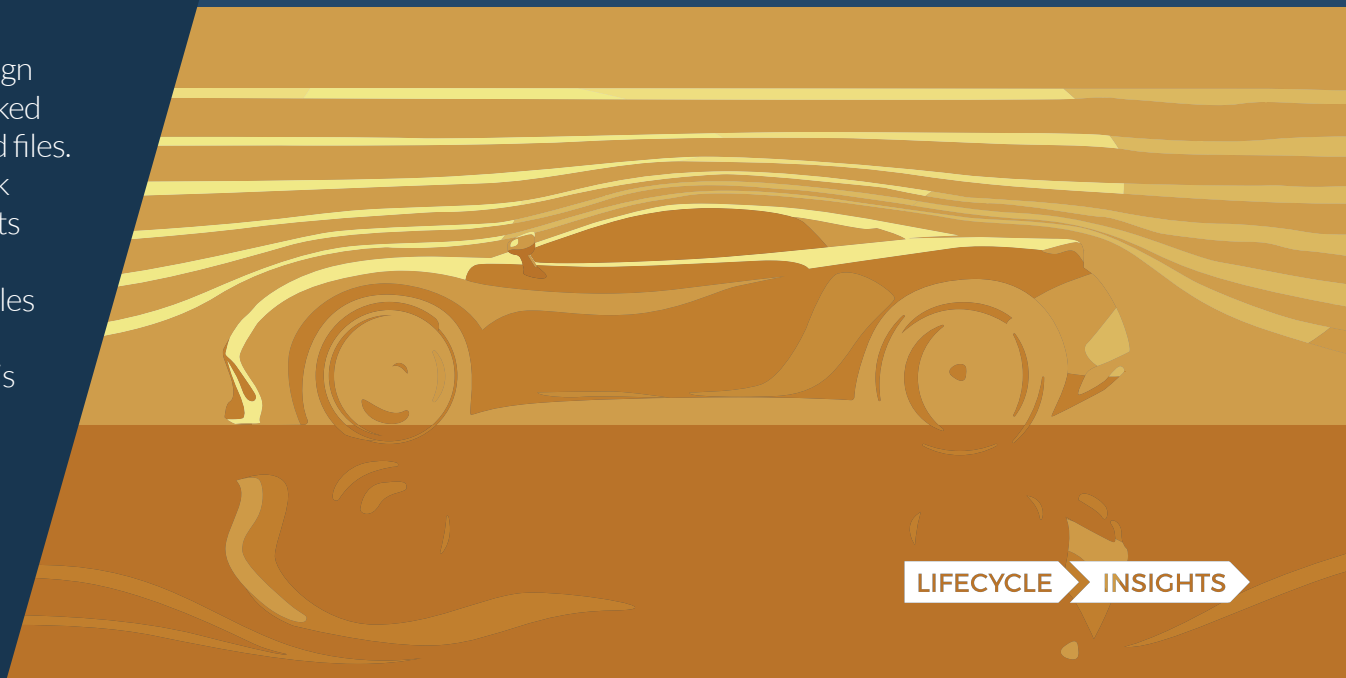
Simulation early in the design cycle helps eliminate infeasible designs. It also facilitates the exploration of more innovative design options that engineers would otherwise not consider. Traditionally, many design engineers avoided simulations because they lacked the confidence and expertise to set up and run them. But there are many benefits for design engineers who use simulation early in the design process, including cost and time savings, easier innovation, and improved product quality. For this reason, it is important for design engineers to gain confidence in using simulation early in the design cycle.

A progressive approach involves analysts setting up templates of validated simulations specific to particular design problems. These simulation templates can then be integrated as a part of guided simulation workflows. Using these workflows, design engineers can then learn how to execute those simulations on their designs. As they learn to use more simulations to guide their design decisions, they become more confident in using simulation.

Proper simulation data management is integral to democratizing simulation. The goal is to support design exploration in an automated fashion. Simulation-backed design exploration creates thousands of artifacts and files. Data management capabilities that automatically link design models, simulation models, and analysis results eliminate ambiguity regarding what results relate to which design. But tracking and linking artifacts and files isn't enough. Decision-makers must also be able to access and quickly extract actionable insight from this design exploration data. Result visualization tools, reports, and data analytics help engineers select the best design that meets all requirements.



The simulation process can be automated and made accessible to design engineers through the use of templates and workflows.

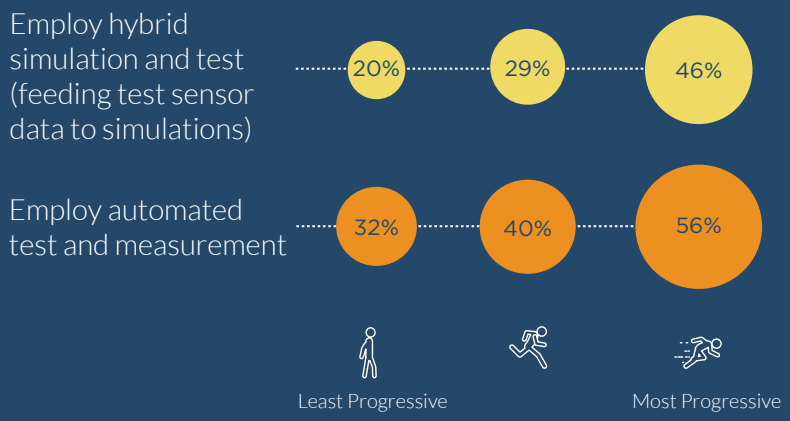


HYBRID SIMULATION AND TEST VALIDATION

Modern products are incredibly complex systems. Traditionally, simulation and testing were done by separate functional departments operating in silos. Yet, simulation and test have synergies. Engineers can take digital insights from simulation to augment physical tests. Test data can also be fed into a digital twin to improve the simulation model. Judiciously combining simulation and test allows companies to accelerate development of complex systems.

The benefits of combining simulation and test apply to both hardware and software components. The sensor data from the physical hardware can be used as inputs in simulation to improve the models. From the software side of things, technologies like software in the loop (SIL), model in the loop (MIL), and hardware in the loop (HIL) can test products under real-life scenarios. The ROI of DX Study supports the benefits of hybrid simulation and test approaches: The most progressive organizations were able to leverage these approaches to reduce the number of product-level prototypes and tests.

Hybrid simulation and test data are also made available to collaborators from all departments. Data management differentiates between test data and simulation data and facilitates comparison and analysis of data between different potential designs.



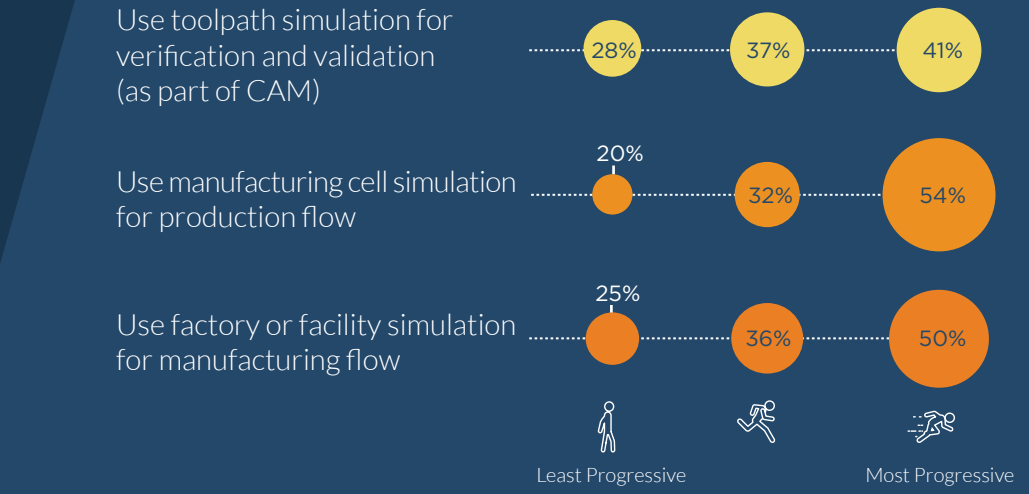
Findings from the ROI of DX Study show that the most progressive employ mixed simulation and testing as well as automated testing approaches at higher rates than the least progressive.

MANUFACTURING PLANNING

Modern manufacturers need to be versatile and able to adapt to market changes. Often, new machines, assembly lines, robots, and manufacturing cells need to be incorporated into existing set-ups. Sometimes, the entire production line needs to be repurposed to support new products or production change requests. Simulating such scenarios on a computer provides critical production parameters upfront.

Engineers can employ computer-aided manufacturing (CAM) tools to generate computer numerical control (CNC) machine code and even simulate the machining process. A 3D virtual model of a production line, manufacturing cell, or factory can help assess material flow, throughput, ergonomics, and safety. Virtual reality tools can be combined with 3D models to train employees on new equipment. The ROI of DX Study showed that the most progressive companies use manufacturing planning to achieve higher throughput as well as fewer days in inventory.

Data management tools can help organizations track part-level design changes and update the corresponding CAM files accordingly. Data management tools provide seamless communication of changes between design and manufacturing, acting as a knowledge base for manufacturing issues.



Findings from the ROI of DX Study show that the most progressive use manufacturing simulation in varying applications at higher rates than the least progressive.

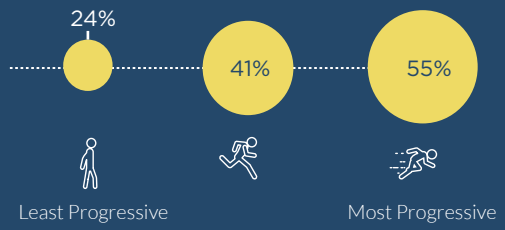
HYBRID SIMULATION AND VIRTUAL COMMISSIONING

Simulation has value beyond design and manufacturing planning. It can also drastically cut manufacturing lines' commissioning time by catching logic and software errors before the hardware is even ready to be tested.

Virtual commissioning solutions verify and can even improve automation logic, programmable logic controller (PLC) code, and other control systems logic on a computer before it is deployed in real equipment. These solutions further enable offline programming of automated production systems to optimize their performance. The virtual model of the production can be linked to a virtual, software-based PLC or the actual hardware. This means the entire manufacturing operation can be simulated and optimized using the hybrid simulation and virtual commissioning tools. The ROI of DX Study found the most progressive organizations used this approach to achieve a higher percentage of early or on-time commissioning of plant and equipment.

Companies that have a robust data management system in place are better positioned to manage, communicate, and process the different data sets that inform commissioning. The system supports user-defined scripts to produce automated charts and reports to guide decision-making.

Virtual commissioning (model-in-the-loop, hardware-in-the-loop, etc.) for PLC programming



Findings from the ROI of DX Study show that the most progressive use virtual commissioning to verify controller logic at higher rates than the least progressive.

GETTING STARTED

Companies that are interested in DX initiatives face a common dilemma: Where to begin? But, as with any transformative project, the most important thing is to start! This eBook highlighted several simulation-related DX initiatives that companies can adopt to improve product design and manufacturing. Companies should set priorities based on the stage of their business cycle and the maturity of the market they currently serve, and jump in from there. Some recommendations for getting started are:

- Define a long-term vision for the company's simulation and test-related DX initiative. Share it in a company meeting to articulate the plan and objectives.
- A variety of stakeholders are involved in any simulation and test-related DX deployment, including initiative owners, functional owners, economic owners, and technical owners. Engage each one of them to make the simulation-and-test-related DX initiative a success.
- Plan the deployment to target something valuable, focus on specific objectives, and measure success with metrics.
- Users are the key to the success of any DX initiative. Employ a progressive training regimen to upgrade their skills continuously.

RECAP AND CONCLUSIONS

Lifecycle Insights' ROI of DX Study demonstrated the advantages of simulation and test not only to design but on through manufacturing to virtual commissioning. Simulation and test can help organizations reduce the number of design prototypes for testing, ECOs, days in inventory, and respins of electronic board systems, to name a few benefits. However, to fully leverage these tools, organizations need a robust data management system.

- The ROI of DX Study shows that the most progressive organizations are already using simulation and test DX efforts to make improvements across the product lifecycle.
- Simulation tools, including hybrid simulation and test approaches, can help design engineers explore the design space, determine the feasibility of different options early in the design process, and use test results to improve simulation models.
- Design engineers are not the only stakeholders who benefit. Simulation and test can also inform manufacturing planning and virtual commissioning efforts.
- Organizations may wonder where to start when transforming their simulation and test tools, but the most important thing is that they do start. Today's smart, connected products demand a smarter, more connected approach to managing the product life cycle.