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Embracing Digital Twins in the Automotive Industry: Interview with PTC

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How digital twins can enhance automotive operations, design, and decision-making using real-time data.

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A digital twin (DT) is a virtual replica of a physical asset that uses real-world data and models to improve operations and aid in decision-making. It incorporates real-time and historical data, as well as engineering, simulation and machine learning models. By creating a digital twin, the automotive industry can gain insights into the performance and behavior of physical assets, optimize operations and make more informed decisions.

The use of DTs in the automotive industry is expected to become more widespread as the digitization of vehicles continues to advance. DTs have the potential to enhance product design, manufacturing processes, and vehicle maintenance, resulting in improved products and a more efficient and reliable automotive industry. As this evolution continues, a key priority will be ensuring functional safety and cybersecurity across various automotive processes. By addressing these requirements, the industry can fully leverage the benefits of DTs while maintaining the highest standards of safety and security.

To delve deeper, S&P Global Mobility initiated discussions with leading players in the DT market, including IBM, Ansys, ABB, rFpro, Digiflec and PTC. All are at the forefront of driving architectural shifts and pushing back the technical boundaries. Representatives of each company share their thoughts on the evolving landscape of DTs.

To learn more about how PTC is developing DTs, we spoke to Michele Del Mondo, global advisor automotive in the commercial excellence division at PTC. PTC is a key player in the automotive industry, leveraging its expertise in digital twin technology to enhance product development and life-cycle management. Its solutions enable companies to create virtual replicas of physical assets, facilitating real-time data analysis and simulation. This capability allows automotive manufacturers to optimize design, improve performance and reduce time to market.

The following is an edited transcript of the conversation.

S&P Global Mobility: What are the most promising automotive use cases for digital twins (DTs)?

Michele Del Mondo: First, to ensure a common understanding, we will focus on the “product” digital twin, excluding considerations of manufacturing digital twins or digital process twins.

Having a product digital twin can provide several benefits:

- Improved decision-making in early design phases: It facilitates design trade-offs by allowing quick addition or replacement of parts and systems, easy material changes, and testing of various configurations in the digital world. This approach saves costs on physical prototypes, speeds up time to market, and enhances energy efficiency and sustainability.
- Enhanced virtual simulation, validation and testing: Leveraging today's unlimited cloud computing power, a product digital twin enables efficient simulation, validation and testing of vehicle performance under different conditions and scenarios. This is beneficial in developing autonomous vehicles where there is high software interaction with numerous aspects across embedded systems and the physical components. This is also part of a growing demand for software-defined vehicles and testing these systems to meet the growing needs for compliance, safety, and quality.
- Shift from experience-based engineering to data-enabled engineering: It promotes a transition to data-driven and virtual engineering capabilities.
- Fostering brand loyalty through customer-centricity: By utilizing real-time data and product usage analytics, a product digital twin can provide personalized services, predict potential issues, alert the driver and recommend preventive maintenance, thereby enhancing customer satisfaction and loyalty.

What are the requirements for an OEM to effectively implement DT technology?

Implementing a true DT requires understanding and implementing the basic components and layers of a digital twin architecture.

Components:

- Real, physical product: The actual physical item being replicated.
- Virtual product: A high-fidelity 3D model that replicates the physical product and the underlying system engineering and software models for the underlying controls.
- Data linkages: Connections between the physical and virtual products.

From a layer perspective, the digital twin architecture can be viewed as an integrated system with three layers, enabled by the digital thread:

1. Base layer or data layer (system of records): This foundational layer includes various data sources and the infrastructure for connected systems. This can include the 3D CAD and PLM data, the Software/Application Lifecycle Management (ALM) data, Simulations, ERP, etc.
2. Integration and orchestration layer: Enabled by the digital thread, this layer creates the virtual vehicle model (Digital Vehicle Record) of the physical product by utilizing and linking data from the data layer and providing analytical capabilities.
3. Engagement layer: This layer encompasses the role-based user interface of applications, allowing interaction with the digital twin and the creation of high-value use cases.

What are the primary challenges associated with implementing DT technology?

The primary challenges in implementing DT technology are most associated with determining what fidelity/aspects of the twin are aligned with the right use cases and the expected business value, given the high initial investment required. In addition to these strategic issues, common challenges often involve isolated and unconnected legacy systems and processes. Effective data management and integration, along with addressing security and privacy concerns, are crucial when implementing DT technology.

How is the pricing structure for the DT scenario determined? Is it based on the complexity of the scenario, the size of the data, or the accuracy of the synthetic data?

Providing a definitive answer is challenging because each company has a unique IT landscape. The complexity of the scenario significantly impacts the costs, but as mentioned earlier, the main cost driver is data management and data integration. Companies that have already implemented a Digital Thread are likely to have a lower cost structure for implementing a DT scenario. In simple commercial terms, pricing for product engineering applications may be on a per-user basis, while scenarios focused on service may be more closely tied to a per-asset basis. The additional costs associated with the implementation are often tied to the use cases being integrated and any specific implementations required for those.

What is considered the new standard for vehicle development time, starting from the design freeze phase to production?

In the past, the average vehicle development time was approximately 60 to 72 months. Nowadays, Chinese car makers claim to develop a full vehicle in 28 months. Considering the increased effort for vehicle homologation, a more reasonable standard for vehicle development is trending from 40 down to 32 months or less overall. While a design freeze may ultimately happen, the objective is moving to drive more concurrency and velocity through the development. Perhaps even allowing for some design changes to occur even in production as timelines continue to be compressed.

Is DT technology primarily used in the infotainment and advanced driver assistance system (ADAS) domains within the automotive industry? Or are there significant advancements expected in other domains like powertrain, chassis and body?

DT technology is not limited to infotainment and ADAS. It can be applied to any part or system, providing significant value. For example, DT technology allows for the creation of new simulation scenarios with different body shapes to optimize a vehicle's aerodynamic resistance. Another application is optimizing the behavior of the powertrain and chassis by considering different driving scenarios based on real-time usage data. Certainly, the most significant realms are around the vehicle controls that are increasingly becoming more software-driven and differentiated, including driver assistance, vehicle safety, and infotainment, but also directly down into the lower levels of the subsystems like the breaking, drive-by-wire, engine controls, etc.

How does the sustainability of digital twins compare to traditional physical development in terms of CO2 emissions? What measures are taken to minimize the carbon footprint of digital twin technology?

Certainly, moving more of the development cycle into the digital realm helps in the overall carbon reduction by attempting to avoid building at least one extra test variant and moving physical tests to become more virtual. Over time, these virtual tests further reduce more demands of maintaining a physical test scenario and all the associated acquisition, logistics, and sustaining maintenance. This isn't inherently new, as this shift left to digital definition. With digital twin technology enabled by the digital thread, it is now becoming easier to integrate sustainability measures throughout the entire development process. This begins with the design engineer, who can use a digital assistant to select materials with the best CO2 footprint based on the given criteria. It extends to manufacturing, where technologies with lower energy consumption and reduced waste are utilized, and to parts shipping, where the entire supply chain network is optimized. In summary, implementing digital twin technology can significantly reduce the product's CO2 emissions compared to traditional development approaches.

How will OEMs and suppliers ensure brand differentiation and maintain brand equity in a market where digital twins may lead to more homogeneous vehicles?

I don't believe that digital twins lead to more homogeneous vehicles. Brand differentiation involves much more than just assembling parts into a complete vehicle. For example, you can have the same automatic gearbox equipped with different software parameters, resulting in completely different driving experiences. BMW, for instance, installs the same automatic gearbox in both the 3-Series and 5-Series, but the 3-Series feels much sportier than the 5-Series due to different parameter settings. Similarly, the iconic Porsche 911 retains its unique brand equity regardless of the implementation of a digital twin. The essence and distinctive characteristics of a brand like Porsche will remain unchanged by digital twin technology. Suppliers can streamline aspects of their portfolio by offering the same mechanical component, the gearbox, or even the airbags while addressing the OEM-specific needs for their application. This is a higher return on capital for the supplier and better potential cost savings across the OEMs.

What proportion of the design, testing and validation processes rely on digital twin models compared to physical prototypes?

If the homologation process for vehicles requires physical testing, physical prototypes will still be necessary. However, with the advent of software-defined vehicles (SDVs) and the increasing integration of ADAS, there is already a significant shift from physical testing and validation to virtual testing and validation using digital twins. To further reduce development costs and shorten time-to-market, relying more on digital twins than on physical prototypes is becoming essential. This is only increasing in interest as we move from maintaining configurations on a per-model-year basis to now allowing more over-the-air updates, including safety-critical capabilities. This requires a higher degree of virtual testing to adequately test and validate the intended outcomes of those updates.

What are the key aspects of digital twins that everyone in the auto industry should be aware of?

A digital twin represents a holistic and continuous approach that evolves over time and requires an upfront investment to establish the foundational architecture. This architecture must be scalable, flexible and easily adaptable to changing market conditions and customer requirements.

Finally, what cautionary advice would you give to those who are hesitant to embrace digital twins?

First, the automotive industry faces intense competitive pressure, particularly from new entrants in the increasing range of diverse options from battery-electric vehicle (BEV), hydrogen and hybrid options to meet the market challenges. Some of these new market players start with a green field, free from legacy and homegrown systems, making it easier for them to establish a digital twin and gain a competitive advantage more quickly compared to traditional OEMs.

Second, for OEMs, a key success factor is customer centricity, especially when a high-quality product is considered a commodity. If a vehicle is not connected and its data cannot be analyzed in real-time, providing first-class customer-centric services and optimizing the development of future car generations becomes challenging.

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