

CIMdata

Transform Development with Altair Digital Twins



Altair One™ integrated capabilities foster trust from design to operation

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Key Takeaways

Takeaway #1

Digital Twin adoption is increasing across many industries, starting with investigations and prototype experiments, and proceeding with process changes that rely on comprehensive models instead of physical prototypes. These physics-based digital twins include usage scenarios and real-world loading conditions such as temperatures, air and fluid flows, mechanical motion, vibrations, noise, impacts, and material deformations.

Takeaway #2

Organizations must learn, adapt, and continually enhance products and services to stay ahead of the competition. Only a fully integrated data and simulation platform that provides digital twins assures ongoing future product and service leadership.

Takeaway #3

Trust flourishes when a digital twin adjusts, through correlation efforts, to actual product use. With a trusted digital twin, end-to-end product testing is possible — and is faster and cheaper than testing with physical prototypes.

Takeaway #4

Operating system digital twins, also known as surrogate models, can improve IT, banking, and healthcare operational and risk management decisions.

Takeaway #5

Sustainability goals are achieved with actionable insight from trusted digital twins.

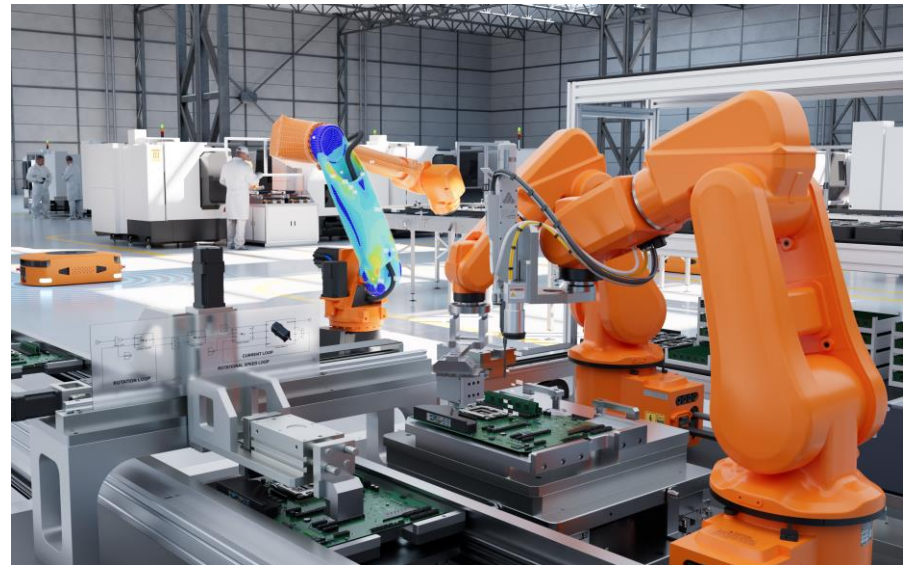
Takeaway #6

Altair One is a total digital twin gateway where simulation, high performance computing (HPC), data analytics, and artificial intelligence (AI) converge through all stages and decisions of the product life cycle. Leading OEMs are changing their processes to make earlier product and operational decisions with accurate, comprehensive digital twins.

Convergence of Simulation, Data, and Computing

Usage Patterns Emerge with Pervasive and Affordable Sensors

The computer revolution predicted by Moore's Law has since delivered many fantastic innovations enabled by embedded computing in phones, watches, and other wearable devices. Complex products like aircraft, ships, and cars have seen benefits for two decades. Sensors that measure our physical world 24/7 are becoming ubiquitous and pervasive. Usage data from sensors provides robust information and actionable insights. Knowledge improves as the sensed usages are shared. In more situations, this sharing occurs as it happens, making real-time interactive traffic, weather, and health monitoring possible. Empirical data from these sensors confirm the accuracy of our dynamic models that learn from ongoing experiences. When data from many experiences are combined, patterns emerge, which help us understand product behavior, weaknesses, and sensitivities. Upgrading products to take advantage of these insights is commonplace today.



Virtual Models Learn from Physical Experiences

Virtual models, the digital surrogates of real-world systems, have streamlined product development in place of physical mockups and prototypes. Even styling cues and lighting are achieved with high-end visualization. The physical system's digital twin makes this possible. But all systems experience loads as they move or as we humans use them. Therefore, understanding the target product's usage makes product models better.

Convergence of Simulation, Data, and Computing

Usage Patterns Drive Product Innovations

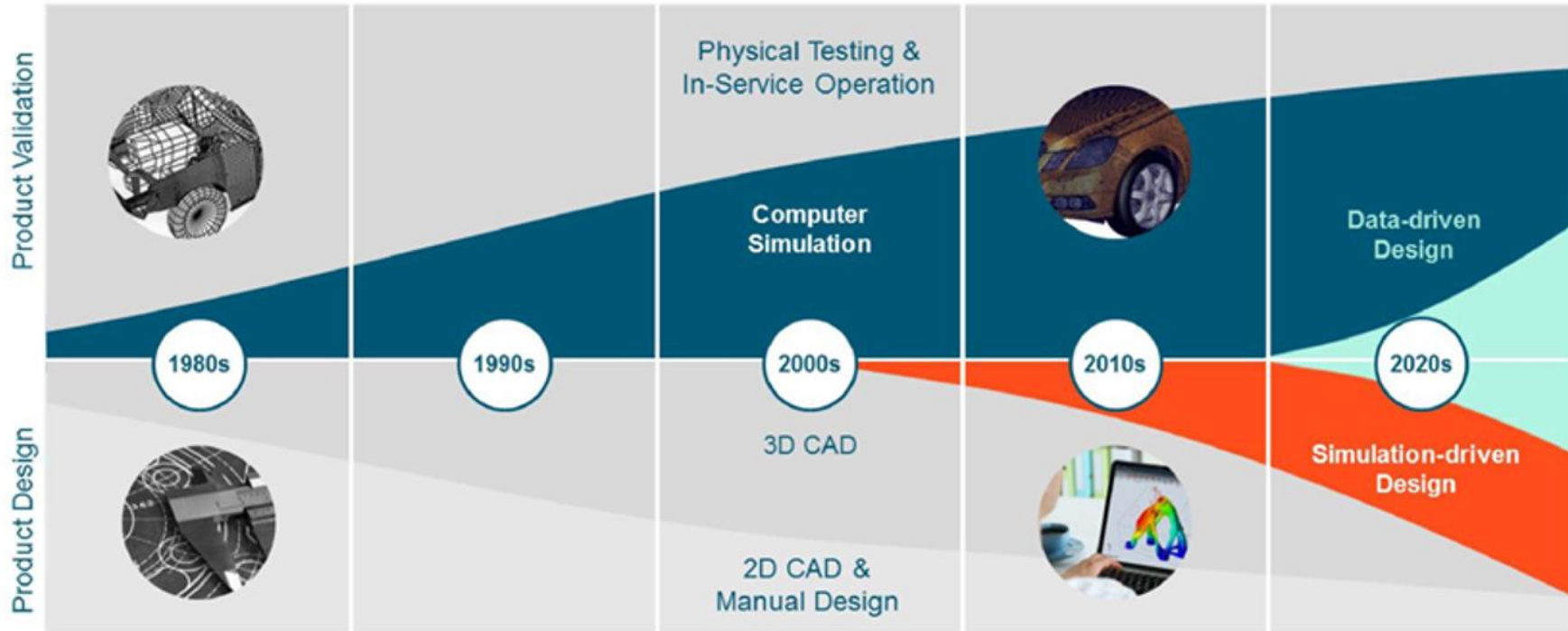
Managing a product's digital representation must account for both the product's 3D geometric model and behavior – the “experiences” that customers expect. Acceleration is about delivering energy to propulsion. Comfort is about the size, location, and movement of the occupant. By determining the forces involved in any movement, experiences such as comfort and acceleration can be represented as load cases that are applied over time. These typical experiences are essential to laboratory verification and validation studies, which ensure that products or services meet customer expectations. Simulation needs these “experiences” to predict system performance.

At its 2019 Global Advanced Technology conference, which was summarized in a CIMdata commentary, Altair introduced the notion that simulation experts are best suited to become the data scientist experts of the future. The point was that the skills of data processing, assessing model soundness and accuracy, and knowing the limits of computers make the simulation expert the ideal data scientist to take full advantage of the next wave of pervasive digital technologies, especially sensor miniaturization and mass production.

“A comprehensive Digital Twin is inevitable. It is simply the most effective approach to understand the impact of multiple parameters on the forming process and based on this improve the quality of the final product.”

Antonio Del Prete, Associate Professor of Manufacturing Technologies, University of Salento; CEO, Advanced Engineering Solutions srl

Evolution of Simulation and Data Driven Design



Altair's Evolution of Simulation and Data Driven Design

Altair's thought leaders constructed a timeline view of the evolution of product design and product validation using HPC and empirical data as shown in the figure above. CIMdata agrees with this summary and has followed, even driven, the evolution of computer-based design over the past forty years. In this eBook, CIMdata explains how Altair expands digital twin

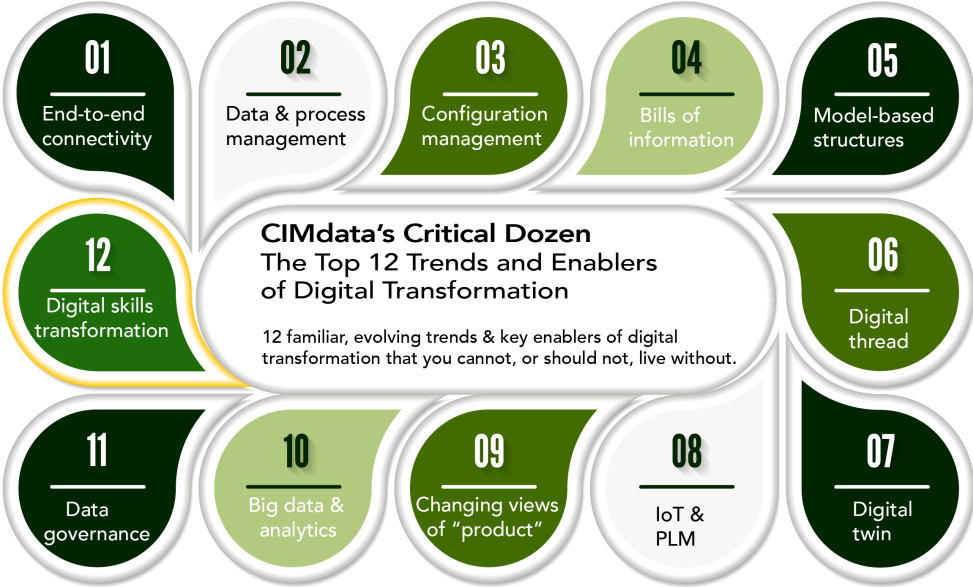
technologies beyond simulation and efficient computing to harvesting system experiences and behavior. Data-driven design and refinement is the new competitive frontier. Using Altair solutions, simulation engineers will become expert data miners not just for new products, but also for upgrades and ongoing operational decisions.

Industry Challenges and Needs

Defining Digital Twin

Annual industrial customer surveys including Altair’s most recent market research have confirmed that industries want digital twins, even though they do not agree on what they are. As is often the case with new technologies, there is a lot of hype about digital twins that causes confusion.

At CIMdata, a digital twin is an accurate digital representation of a product and/or service at any point throughout its life cycle. CIMdata identifies digital twin as one of the top 12 trends enabling digital transformations, summarized in the figure.



CIMdata's Critical Dozen

Whenever a decision is needed, a digital twin can exist to help put all data into context. Predictions based on digital twins become more trustworthy as digital twins stay current with experiences.

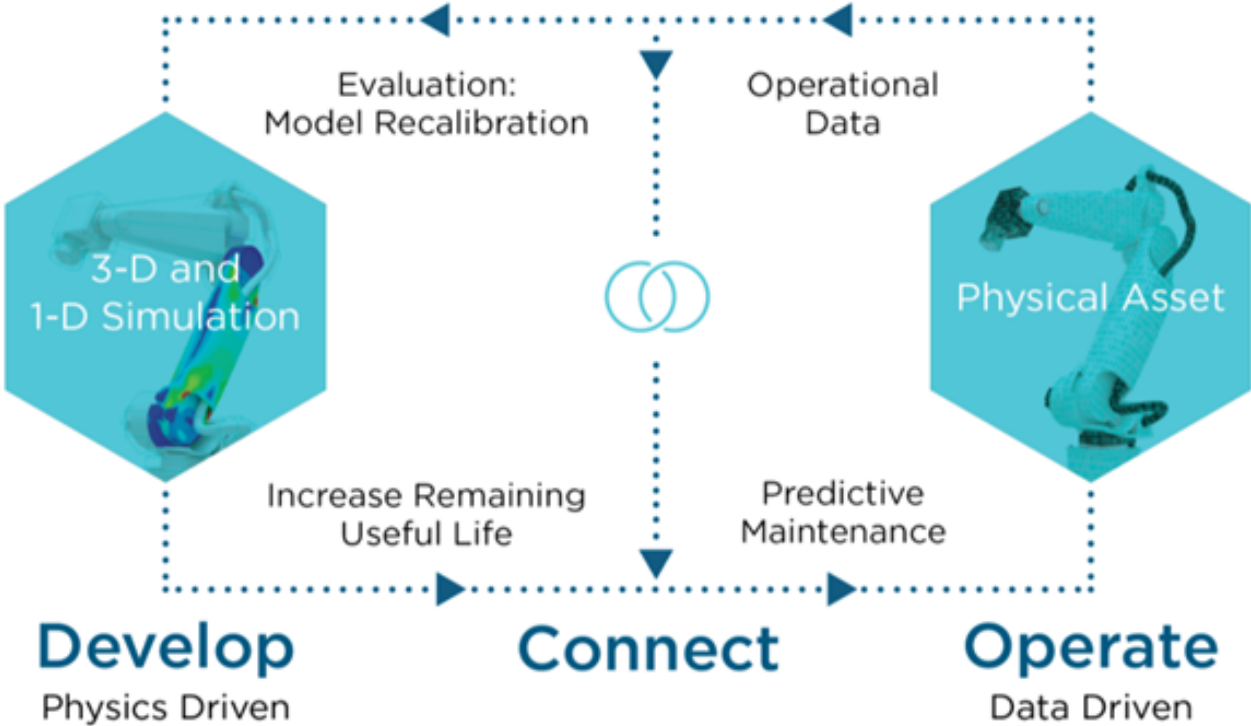
Trusted digital twins capture actual product usage wherever and whenever the experience is discovered. They must cross multiple domains when needed, and they must use HPC resources efficiently. This means that digital twin is much more than a product bill of material (BOM). Product BOMs rarely include performance requirements and the related simulations that improve decisions made during a product’s design and use.

During Altair’s [2022 Future.Industry](#) conference keynote, founder Jim Scapa cited Professor Karen E. Willcox’s digital twin definition: “A personalized, dynamically evolving, model of a physical system...grounded in physics, assimilating data from inspections, sensors, and other relevant sources.”

Digital twins are useful as a surrogate for a physical product when making decisions. In fact, once correlated, digital twins are faster at predicting performance and exposing product sensitivities than physical testing. Using digital twins brings a competitive advantage that improves time to market and product performance.

Connect Simulation, Data, and Computing

Altair continues to focus its R&D on digital twin technologies following its 2019 vision, shown below, which depicts how simulation and data are both critical. The intelligent connection is essential and remains Altair's focus.

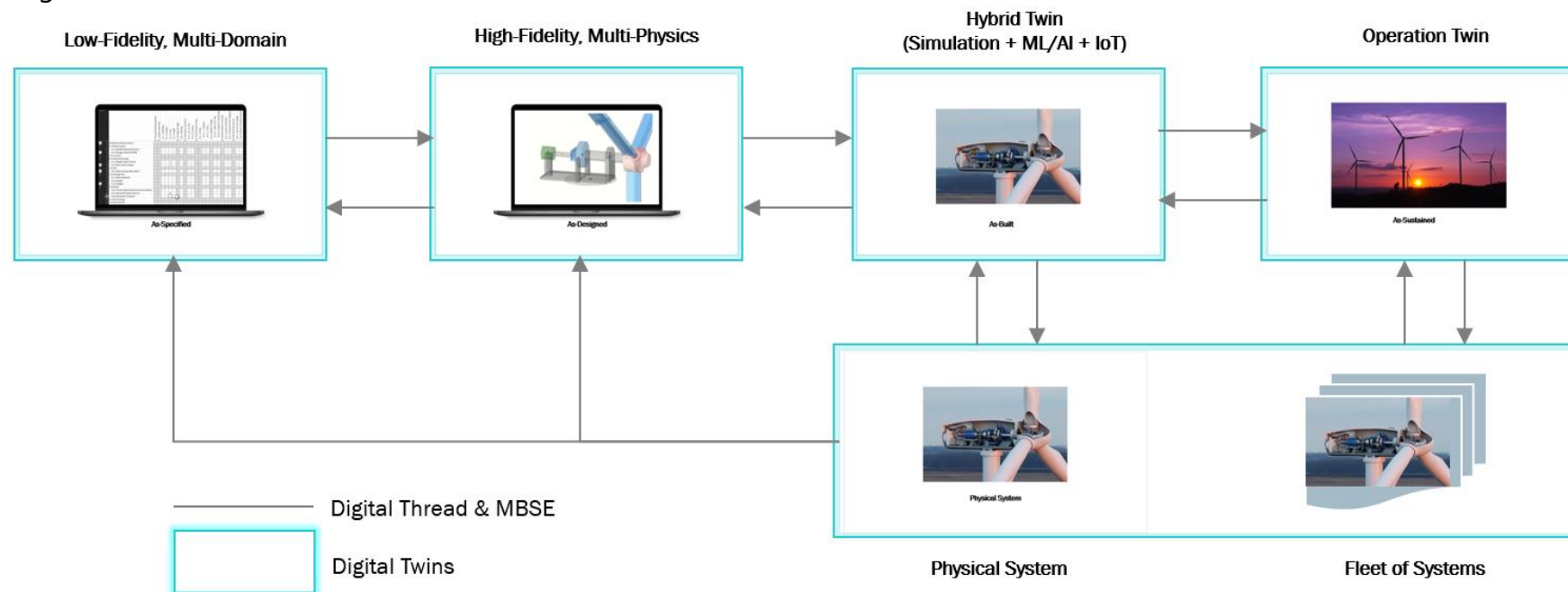


Altair's 2019 Vision Connecting Simulation and Operational Data

Altair Identifies and Supports Different Digital Twins

Insights from the recent industrial customer surveys like the one Altair conducted ([page 20](#)) are driving the need for not only definitions, as we summarized on [page 7](#), but for refinement in digital thread and model-based systems engineering (MBSE) capabilities bolstered by real world testimonials. The following figure shows Altair's digital twin framework, which covers each phase of product development including operations. Note that the framework encourages collaboration by sharing contexts. The models and data work together to build confidence that nurtures trust. Trust that is

proven by experience fosters clarity and confidence to change product development processes. Operations become digitally-based as IoT and management dashboards are connected to the digital twins. Usage insights then drive all phases of development to consider broader views. Following this framework, MBSE applications and data analytics together are driving the need for a new platform that improves functional collaboration.



Altair Realizes Many Digital Twin Possibilities

Altair One: Converging Technologies

The Altair One cloud innovation gateway gives users access to three platforms:

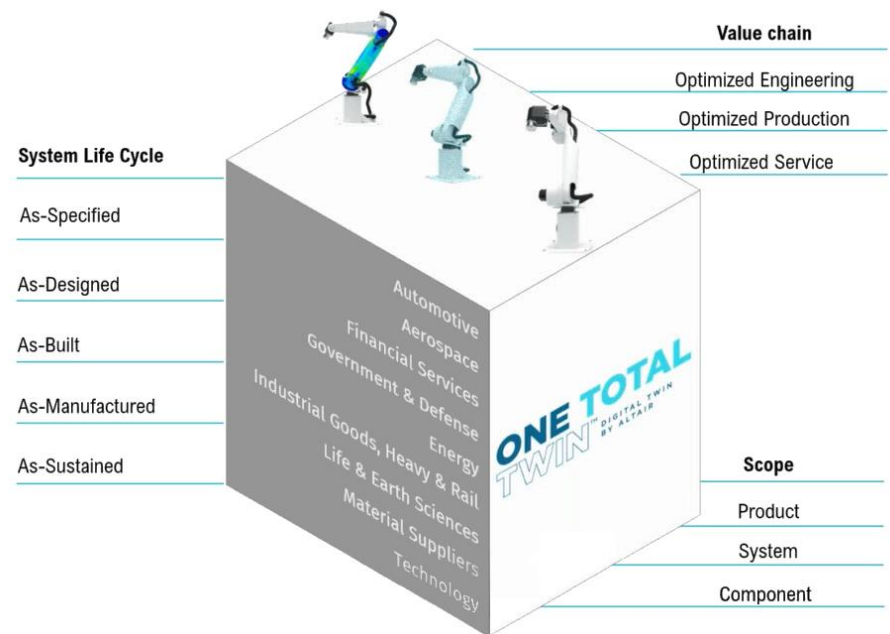
- Altair® HyperWorks® simulation and design platform
- Altair® HPCWorks™ HPC and cloud platform
- Altair® RapidMiner® data analytics and AI platform

These platforms support holistic digital twin creation, evolution, and management for the different types of digital twins needed at different stages of the product life cycle.

Altair starts with simulation expertise wedded to data analytics, which creates the digital thread that connects all digital twins in a system's life cycle through multiple contexts and systems of systems. As products become more complex and better connected, continuous, always-integrated engineering solutions make the learning loop faster with on-demand digital twins.

A system's life cycle has many kinds of digital twins: "as-specified," "as-designed," "as-built," "as-manufactured," and "as-sustained." But to understand a full system with its behavior, features, and functions in all usage contexts requires an additional digital twin: "as-used." The as-used digital twin expands our understanding of real-life product usage.

This total-twin approach enables companies to introduce improvements, services, and features as needed during the product lifetime that increase customer satisfaction and generate new revenue streams.



Altair's One Total Digital Twin Solution

Altair One In Use

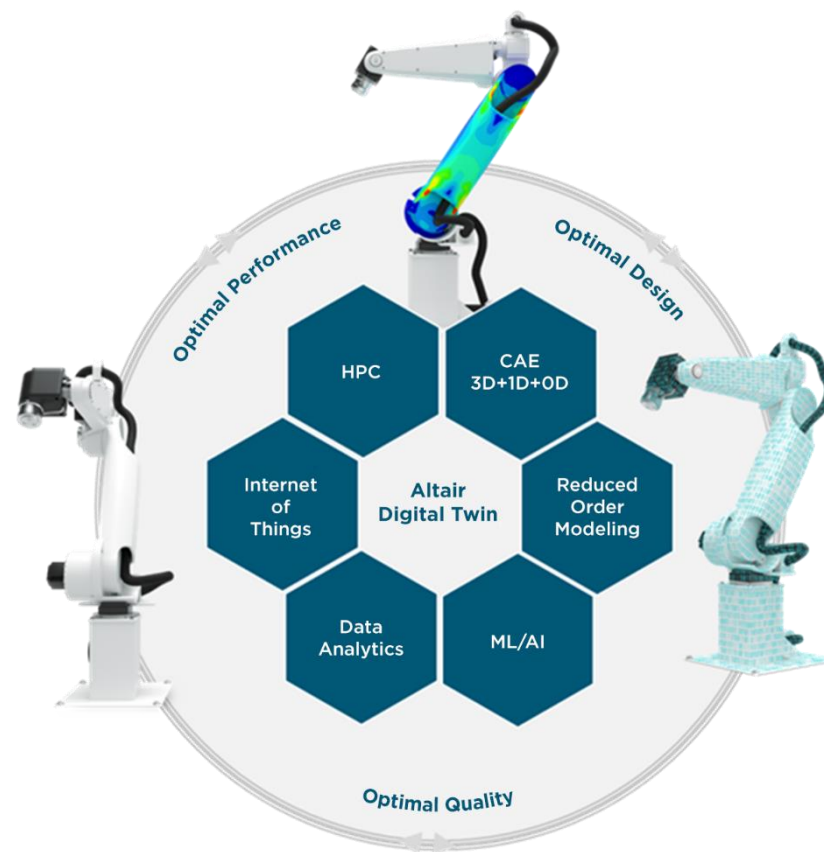
Maintaining an MBSE digital twin with the latest customer usage is essential to inform decision making. A total twin solution like Altair's with its integrated, single ecosystem provides this. To further enrich this ecosystem, Altair has widely expanded data analytics capabilities with the acquisition of Altair RapidMiner, a data analytics, AI, and machine learning (ML) platform.

Industry needs digital twin convergence with proven simulation, data analytics, AI, and HPC capabilities, and Altair is addressing this need with the Altair One cloud innovation gateway, which offers access to flexible platforms that enable different experts to collaborate easily on-premises or in the cloud. At [2022 Future.Industry](#) and [2023 Future.Industry](#), Altair

“Altair’s data visualization and machine learning tools help us predict possible failures in the field, understand how our customers are using our products, create more efficient development strategies, and improve customer satisfaction. The software’s explainable AI capabilities enable us to understand all the factors that contribute to maintenance.”

Martin Ortega, PhD, Senior Engineer, Mabe

presented the breadth of progress being made with testimonials from its customers. These customers highlight the benefits of using trusted digital twins at different points in the product life cycle.



Altair One Offers Broad Digital Twin Capabilities

Continuous Improvement

Harnessing the Power of Big Data, AI, and Simulation

Mabe, a leader in home appliances, is leveraging the convergence of big data, analytics, and simulation to accelerate washing machine innovation. Mr. Martin Ortega, senior design engineer, explains how the company is using Altair's AI, data analytics, and simulation solutions to uncover insights, create new business opportunities, and advance product development. A summary of their multi-disciplinary approach explains how Altair One improves product energy consumption, increases load capacities, all while reducing time to market. Key to this achievement is the ability to better understand how customers use their appliances. When

connected via IoT, data collection during use directly from the appliance is faster and more accurate instead of relying of customer surveys and interviews. AL/ML will detect patterns across many washing cycles from different households. Engineers can explore possibilities beyond the customer experience by extending the adapted simulations to more extreme load cases. Prediction of failures becomes more and more common, even for mass market appliances like washing machines.



“We greatly value the breadth and depth of Altair’s technology – and the expertise of its consulting engineers. Over a period of 12 years, we’ve never hit any walls or show-stoppers. Every time we have wanted to expand our simulation capabilities, Altair has helped us do that.”

Martin Ortega, PhD, Senior Engineer, Mabe

Connected Appliances Training Digital Twins

Broad Systems of Systems

Understanding Energy Flows and Storage Capacity

Switch Mobility uses Altair solutions to refine and predict battery performance for its emerging fleet of city buses. Performance includes:

- Duration of discharge, which determines route range based on terrain.
- Speed of recharge, which determines bus idle time.
- Electro-mechanical balances during stop and acceleration.

By combining best-in-class data analytics with field measurements from actual bus routes, Switch Mobility can quickly adjust bus performance models as their initial fleets deploy. Improving their understanding of which operational conditions affect performance is key to success with electric propulsion in large city buses. The resulting intelligent digital twin accurately predicts range and continues to learn as more routes are executed. This capability will continue to improve understanding as bus fleets are deployed in different cities. Upgrades and future products will meet the municipal goals for sustainability by accurately predicting range.



“Altair has a wide range of software capabilities and engineering support. This is one of the most important parameters you consider when working with your engineering partner.”

Selcuk Sever, Principal Engineer, Switch Mobility

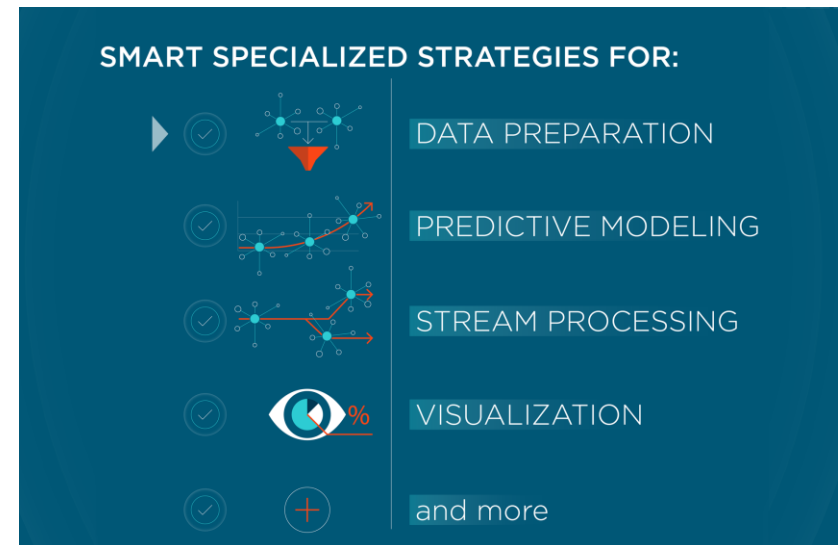
Captured Fleet Experiences Make Digital Twins Intelligent

Value Chain Optimization

Digital Twins Across Supply Chain Improve Logistics Understanding

Tech Mahindra presented its Supply Chain Control Tower at the 2022 Altair Future Industry conference. Leveraging factory and operational measures using Altair One AI/ML capabilities, the company configured a management dashboard that provides real-time insights to flow within the supply chain. The ability to create mathematical models tuned to actual operational performance enables a company and their suppliers to continuously monitor and adjust supply chain performance and as a result effectively manage disruptions.

Reviewing a supplier's operational readiness and manufacturing robustness can be enhanced with a trusted digital model of their key machines and factories. Suppliers can also gain insights on how components are being delivered and handled in the factory by viewing a digital twin of material flow. The confidence in these factory digital twins improves as real-time monitoring reveals actual handling. Monitoring data during manufacturing helps all parties through to the final product mass production, which improves production efficiencies while assuring quality. Imagine how manufacturing improves across the supply chain with Altair's strategies for data preparation, predictive modeling, stream processing, visualization, and more, noted in figure.



IoT and Data Intelligence Improve Operations Within Mass Producers and Across their Supply Chains

Tuning Product Performance

Gruppo Cimbali and the Physics of Making Great Coffee

Professional coffee machines are thermodynamic systems with key components for heating and pressurizing a fluid to perfectly brew coffee. To get the best possible quality (taste, aroma, texture), you must understand how the physics and system components contribute to quality and customer preferences. The relationship between peak heating

temperature, high-pressure steam, and customer preferences is easier to explore in a model that is based in physics and correlated to customer feedback and IoT empirical measurements using data analytics. Developing a digital twin to get more insights helps product optimization during development and operation.



“Innovation is a key element along with the group’s effort to fully embrace digital transformation brought into existence by the digital twin project with Altair.”

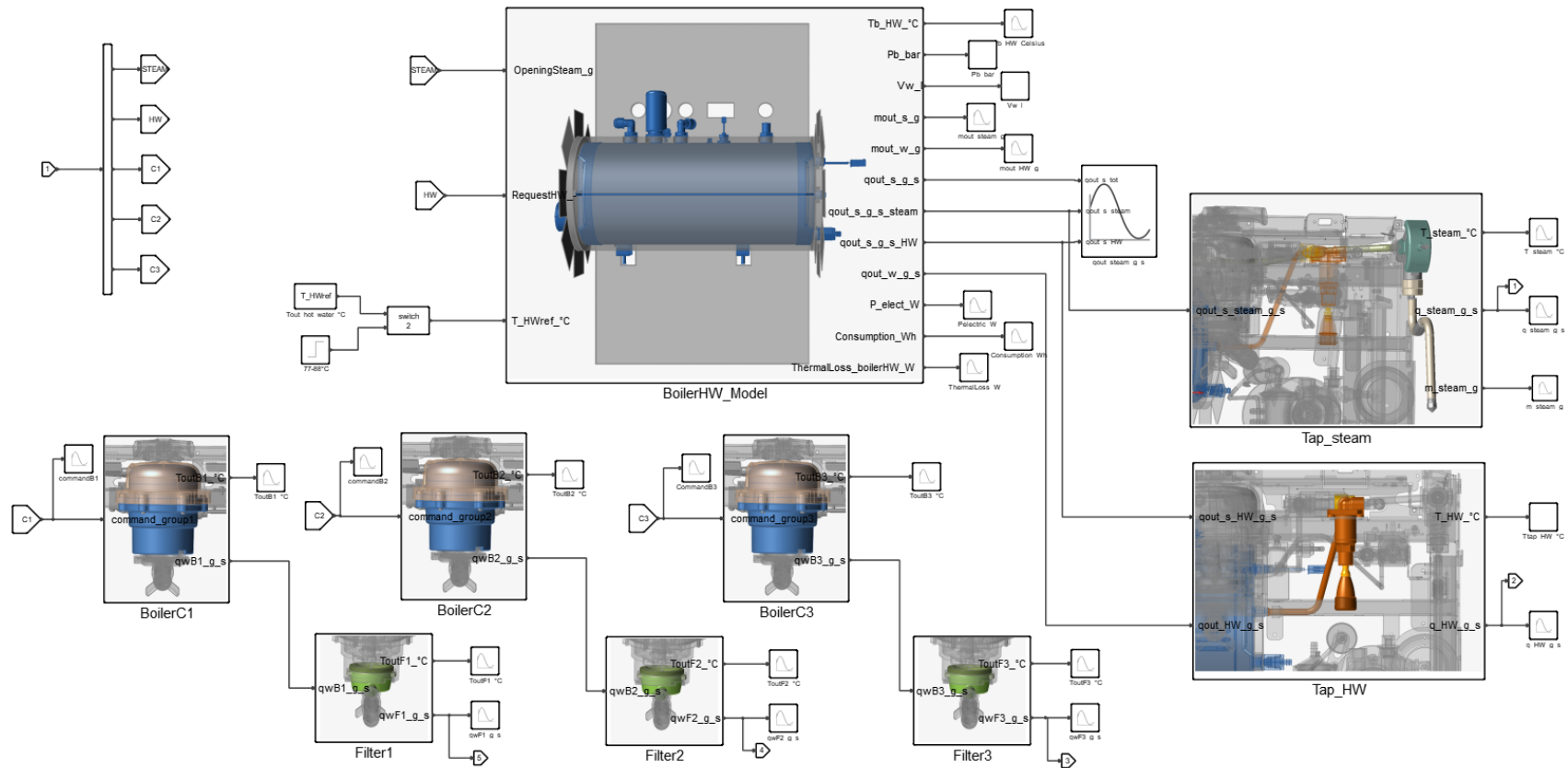
Maurizio Tursini, Chief Products and Technologies Officer, Gruppo Cimbali



Tuning Product Performance with Models

Gruppo Cimbali and the Physics of Making Great Coffee

Gruppo Cimbali builds its digital twins using Altair One capabilities to cover high-fidelity multiphysics. This reduces physical prototypes, enables visualizing the espresso machine in operation, and improves models according to collected usage experiences. Knowledge resides and grows within the digital twins and informs the next iteration of product improvements.



Digital Twin Provides Performance Context for Key Components

Using Digital Twins to Better Comprehend Systems

Connecting Physics and Real-World Data for Meaningful Digital Twins

Connected and informed by empirical data from the field with the help of AI, Leonardo S.p.A. virtually validates product system performance in the early stages of design to accelerate the development of next generation products for its targeted aerospace and defense business areas. The digital twin evolves as it learns from collected field data during product development. Collected data comes from both laboratory measurements and simulation results from trusted models.

The simulation models are improved as more measurements are made. This is reflected in a feedback loop that can infinitely optimize product design, development, and maintenance. CIMdata and Altair have described Meaningful Models, which have the accuracy needed for the next product decision. Leonardo and Altair are now showing us how to keep digital twins meaningful.



Continuous Sensing and Learning Makes Digital Twins Meaningful

Financial Risk Management Improves with Digital Contexts

Data analytics combined with digital twins provides better risk management practices. Risks driven by fraudulent activities are easier to find with deep learning, a form of compute-intensive pattern matching, or pattern dissonance, which helps lenders monitor and then decide if corrective actions are needed.

Altair's RapidMiner combined with HPC Works are two strengths that are benefiting financial services. In this example, the digital twin is the expected operation. When compared to a measured operation, the digital twin reveals if anomalies are fraudulent or just a new way of banking.

Digital Twins for Credit Scoring, Credit Risk, and Financial Services

- Detect fraudulent activities via Altair's deep learning.
- Score applicants of risk-based products or create a predictive scoring of credit line to better understand who might be at greater risk to default on credit loans.
- Remove the complexity of developing a marketing analytics campaign by automating and repeating processes used in ML models designed to show the probability of success.



Financial Institutions Need Advanced AI/ML

Sustainability Investments Improve with Digital Contexts

How the world responds to the climate challenge and circular economy will determine the future of generations to come. Technology is a vital enabler of sustainability. The expanded reach made available through the convergence of simulation, HPC, data analytics, and AI can help companies achieve their sustainability goals faster.

A panel discussion was held at the [2022 Future.Industry](#) conference discussing Altair's digital twin capabilities and how they could help address sustainability challenges.



The panel's conclusion:

Digital twins will accelerate sustainability innovation.



Experts Discuss Innovation for Sustainability

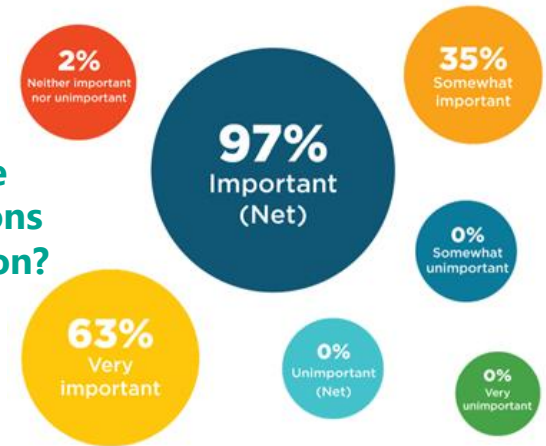
Digital Twin Global Survey Report

In step with its “only forward” motto, Altair wanted to understand the complete picture of digital twin technology and its adoption. To achieve this, the company surveyed more than 2,000 professionals around the world and created a [Digital Twin Global Survey Report](#) that answers the most pressing questions surrounding digital twin technology and the organizations that utilize it. Here is a sampling of the findings:

- Companies around the world are adopting digital twins at astonishing rates—69%. In companies that don’t already invest in the technology, many are looking to do so in a matter of months.
- One of the most definitive findings was that 92% of respondents that used digital twin technology said it made their products and processes more sustainable. 73% of those said that the technology made their products and processes less wasteful or more energy efficient; 41% said the technology made it easier to refurbish or reuse products.
- Common impacts from the technology are real-time monitoring and control (38%), efficiency and safety (37%), and cost savings (33%).
- Responses revealed a disconnect when it comes to understanding digital twins. Data suggests people could benefit from a more standardized conceptualization and definition of digital twin technology.

- 43% of respondents thought that digital twin solutions will make physical testing obsolete within the next four years or sooner. Only 4% of respondents said that digital twins would never make the need for physical prototyping go away.

How important are digital twin solutions to your organization?



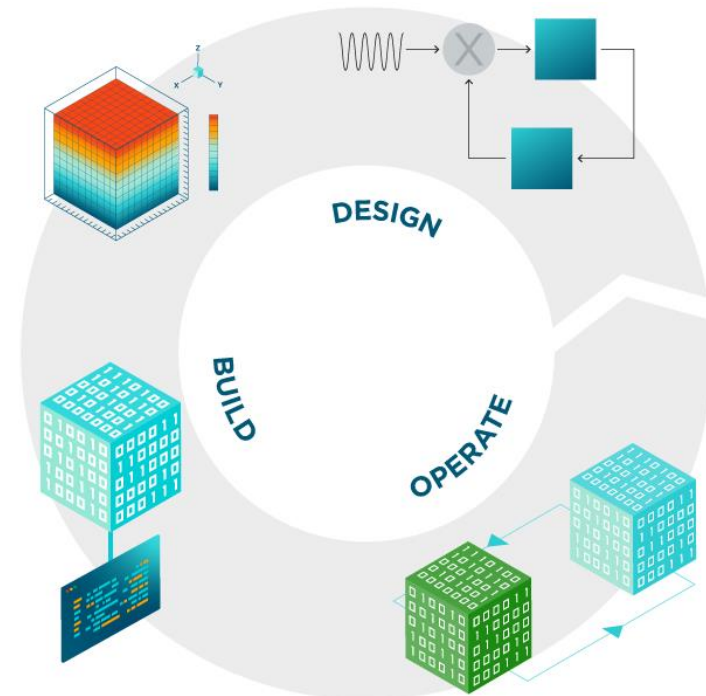
The survey reveals that digital twin technology will be a critical part of future design and production, and that early adopters will have a head start on bringing better, more sustainable products to market, faster than the competition.

Clearly Altair’s knowledge and capabilities discussed in this eBook are spot on to address the technology and support companies require for the best digital twin adoption, usage, and return on investment.

Digital Twin Management Solutions

Digital twin solutions must support closed-loop development processes that encourage learning across the complete life cycle. Comprehensive configuration management is a keystone for effective digital engineering solutions. Digital twins needed for decisions are configuration elements. Making sure digital twins learn from their physical twins' on-going experiences that are captured by pervasive IoT sensing is paramount to keeping digital twins useful and ultimately transformational for any product, system, or process.

Leading companies have used Altair's simulation solutions for decades. By converging best-in-class data analytics and AI into its proven simulation and HPC expertise, Altair has built a unified ecosystem to improve collaboration across disciplines. These capabilities are being applied beyond product development and manufacturing and into operations—even operations as diverse as banking and health care. The Altair One gateway with access to on-demand digital twin solutions is designed to keep teams collaborating from start to finish, improving decision-making across an extended enterprise.

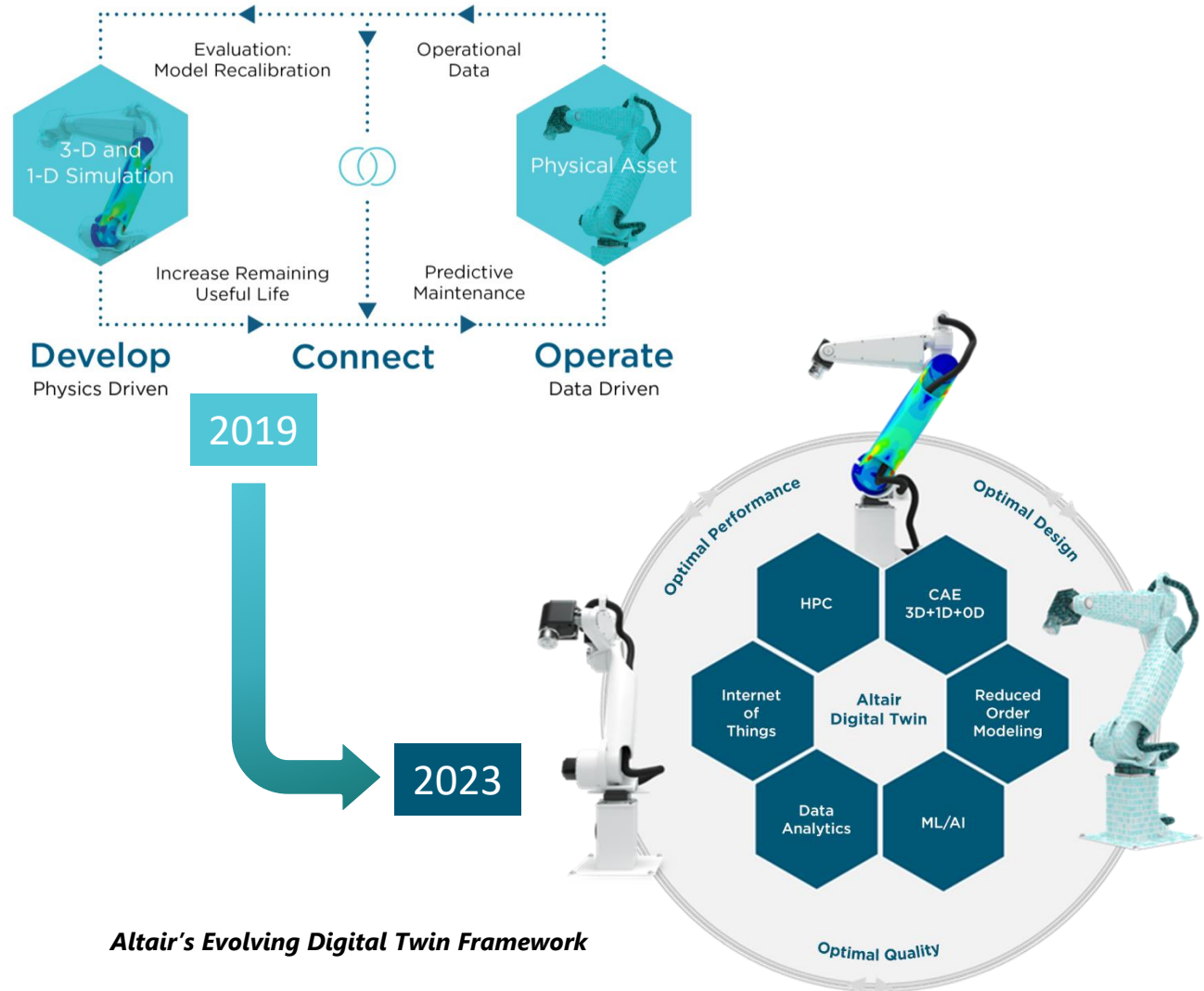


Altair Digital Twin Life Cycle Framework

Altair Introduces ONE TOTAL TWIN

CIMdata and Altair have conducted research on the awareness, adoption, and importance of digital twins and how they can keep models meaningful.

The evolution to One Total Twin from Altair's original 2019 vision is inspiring. It is clear how companies have embraced Altair's vision and gained substantial efficiencies, cost savings, sustainability, and product improvements. These accomplishments are driving Altair's digital twin solutions to be even better. Just what you would expect from a learning organization—and just like a maturing digital twin—Altair continues to build on its expertise and expand the horizons and usefulness of computer-aided-engineering into accelerated and transformational engineering. It is enabling a holistic digital thread for product life cycles from development through operations, making sure the latest experiences are captured through its simulation, HPC, data analytics, AI, and machine learning capabilities.



Altair's Evolving Digital Twin Framework

About Altair

Leading convergence of computational science and AI, Altair is at the forefront of the evolution toward a smarter, sustainable, more connected world.

Altair can help companies like yours use digital twins, intelligent models, and the convergence of simulation, HPC, data analytics, and AI to predict and optimize system outcomes. To learn more, visit: <https://altair.com/one-total-twin/>

Ready to transform your development?

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