ALTAIR

NAVIGATING DIGITAL TWIN IN AEROSPACE

INTRODUCTION

Digital twins promise to reduce the need for physical prototypes, optimize designs, and help make products smarter, more connected, and more sustainable. They have the potential to be a single source of truth from conception to production to in-service—the full product lifecycle. It's a transformative technology for the aerospace and defense industries, driving innovation in record time. But the process of adopting digital twins can be daunting. Digital twins' bedrock components: simulation, high-performance computing (HPC), and data need their silos disrupted, their processes converged, and their collaboration around assets leveraged in real time.

Additionally, enterprises need seamless integration between the computing cloud and on-prem, with security concerns and data flow managed appropriately. It's no wonder the process of adopting and using digital twins has led companies to hire VP and C-level digital transformation officers to steer this process.

In this eGuide, we'll address key aspects of digital twin technology, and will help you understand:

- **Distinguishing digital twins**: Why physics-based twins are different than machine-learning twins.
- **Managing silos and convergence**: Understanding how to blend big data, HPC, and simulation is critical.
- **The value of vendor flexibility**: All-in-one systems are rarely up to the challenge, especially for the aerospace industry.
- **The importance of mixing and matching the right digital twin components**: Buy what your enterprise needs when you need it.
- **Choosing the right mix of Cloud and on-prem**: Understanding when Cloud is the right choice and how to use it securely.
- **Exploring the potential of predictive maintenance**: Digital twin technology supercharges the analytics behind predictive maintenance.

We will highlight case studies of an aerospace company successfully using digital twin technology to streamline development and save money.

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The following content defines digital twin and describes its landscape, challenges, value, and application in the aerospace industry.

What do we mean when we say digital twin? It's the process of using advanced simulation combined with data streams to create a digital representation of a real-world asset that improves collaboration, information access, and decision-making.

THE DIGITAL TWIN LANDSCAPE

Aerospace companies and the manufacturers that supply parts to the industry are a natural fit for digital twin technology and have adopted it more quickly than other industries. 75% of Air Force executives consider it important, Juniper Research 2021.

McKinsey writes: "To reach the next horizon of engineering productivity, speed, and quality, the sector will need to place a new emphasis on analytics-driven productivity and the digital twin—areas many companies are already starting to explore, but in which there is still significant opportunity to accelerate and scale efforts. For instance, only 35% of A&D firms in this study reported that they use digital and analytics to inform their product designs or improve throughput and quality in their engineering function. Because engineering forms the basis for everything else in the value stream, the impacts of these inefficiencies are wide-reaching, extending deep into the quality and productivity of the supply chain, manufacturing, and operations."

More broadly, in the independent international survey we commissioned earlier this year, 69% of professionals said their organization currently leverages digital twin technology. The vast majority (95%) of those using the technology indicated they do so to better inform new product development. While that's remarkable, what's particularly outstanding is that companies are looking more broadly at incorporating digital twin technology into the system lifecycle. Organizations are using digital twins for jobs like monitoring devices (50%) and creating smart objects (50%). And 85% are using digital twin technology to meet sustainability goals, something the aerospace industry is acutely tuned to.

As companies are discovering, digital twin technology can be used for much more than product development. From prototypes to beta testing, manufacturing to maintenance, sustainability to materials selection, and the known to the what-ifs, digital twins can reduce costs without needing to reduce system complexity. But not all digital twin technology is interchangeable. Some companies offer products labeled as digital twin that are simpler digital representations built using machine learning. These "twins" don't offer rigorous, high-fidelity simulations that incorporate physics, geometry, modeling, and data. Nor do they offer users the ability to modify, iterate, and collaborate in one ecosystem.

While a machine learning digital twin might be appropriate for some aerospace needs, a physics-based digital twin has no substitute.

MANAGING DATA SILOS AND CONVERGENCE

Before you can build a robust digital twin, you need to manage the data that will inform it. The idea of having a single source of truth, or the ability to track a virtual model against a real-world system from conception to production to in-service lifecycle, brings significant challenges. Who owns and manages the data? How is data shared between suppliers, manufacturers, and end users? How are vast amounts of sensor data stored and made available?

Typically, data ends up in silos – which leads to multiple sources of truth. Further complicating the single version promise is that it's common in the aerospace community to have a separate digital twin that's unique to the aircraft's serial number.

It's also common for the work to be divided in a way that makes the single version of the truth hard to come by. Different teams work on the simulation, the HPC elements, and the data management and analysis. Ultimately, these three areas need to converge.

To converge and bust silos, tools that support digital threads and model-based-systems-engineering (MBSE) practices are critical. Digital threads support version control and tracing to the twin's origin. MBSE shifts document-centric linear processes to non-linear, collaborative, and digital bases. MBSE is the default standard in aerospace and defense, but not necessarily the default standard for digital twin tools.

A solution that enables deep cross-functional and enterprise-wide access and collaboration across disciplines is critical.

The Value of Vendor Flexibility

Convergence isn't possible if you select tools and solutions that don't play well with others. Open-source, open-architecture, and low-code options are critical to growing digital twin usage. Many closed systems aren't flexible, don't have strong UX, and are cumbersome to implement and deploy. They might not allow data importing from other systems like ground stations or communication satellites.

Committing to a tool that can't integrate with other tools to form full systems portends expensive rip-and-replace jobs in the future. Tool-independent standards are the backbone of holistic system integration. Two of those systems to consider include:

HDF5: Hierarchical Data Format version 5 is an open-source file format. It supports large, complex, heterogeneous data. You can organize the data structure in many ways.

Functional Mockup Interface: A standard for exchanging dynamic simulation models. Aerospace companies shouldn't rely on digital twin tools that require proprietary or binary data sources because data might need some manipulation for teams to gain meaningful insight from it, such as stripping out redundant parts, combining different data types and sources into a single file, and generating reduced order models.

For handling data in this way, enterprises will need to leverage artificial intelligence (AI) and machine learning so that they can determine what data is actionable and predict future outcomes based on past data. Not all tools offer this.

Another important consideration is speed. With vendor flexibility, aerospace startups (such as those in the eVTOL space) can move more quickly to innovate, develop, and certify at record pace to capture market share before competitors.

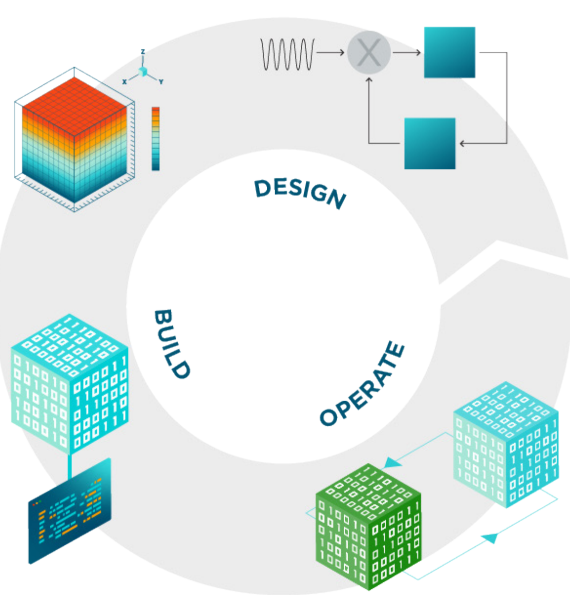
Questions to ask tool vendors:

- Do the products use open containers that can seamlessly interact and share information with one another? This helps enterprises buy and adopt at the pace that works for them.
- Are the tools scalable?
- Are the tools using powerful, flexible, and open architecture solutions such as OpenMatrix?
- Do the tools natively support and integrate with languages such as Modelica? This open-source standard in cyber-physical systems along with Python are critical languages for flexible digital twin work.
- Does the vendor participate in open-source-centric organizations like OpenRadioss™?
- Does the digital twin solution cover the complete system lifecycle from design to build to operational life?

Choosing the Right Components

Digital twin technology is an umbrella term for a lot of different tools and functions. You might need AI for augmented simulation, and virtually all aerospace companies need physics-based components. Aerospace vendors will need HPC lattices for additive manufacturing. A complete system digital twin incorporates multiple twin types, and it's important to understand the differences between them and the tools used to create them.

As-built twins let engineers ask what-if questions, deploy reduced order modeling (ROM), assess test failures, detect design sensitivities, and optimize system performance. With as-built twins, real-time visualization is critical for resolving test failures.



As-manufactured twins serve to test controls design, validate, and predict mechanical loads more realistically; evaluate human driver controls, ergonomics, immersion, and virtual reality; simulate realistic and unexpected events; analyze workability and operation window; and produce a high-fidelity display of innovations in interactive and realistic environments.

Adopting Flexible, Cost-Effective Data Approaches

One of the potential hurdles in digital twin adoption across the lifecycle is data storage. Storing and accessing the data that makes the digital twin useful is costly. Digitally storing elements of a jet can consume thousands of terabytes – now multiply that for the individual digital twin created for every airplane.

Commissioning on-prem servers is cost-prohibitive, especially as the need to access, use, and store data ebbs and flows. Adopting cloud computing is important. Not only can you pick and mix and match as your needs change, but you can also make the transition to edge computing where data access, computation, and storage are closer to data sources. Cloud-based technology vastly improves the affordability and availability of the computing power required to run large-scale digital twin models.

While customers are likely going to demand more and seamless integration to the cloud and all the HPC resources that it has to offer, there will be concerns:

- How is security addressed?
- What's the service level agreement (SLA) for uptime of data stored in the cloud?
- How can hybrid environments work? Will that cause duplicative data, or can it be managed?

DIGITAL TWIN AND PREDICTIVE MAINTENANCE

Digital twins can blur the line between the physical and digital worlds. This can help aircraft operators extend the life of their fleet, while manufacturers gain insight into how to do that from the design stage. Using digital twins, engineers can determine the life of structural components. They can then use this information to improve performance, generate savings, and/or increase operational flexibility.

This is different than predictive maintenance, which relies on analytics to model the point when something should be serviced. The digital twin can model real-time wear and tear, reducing lag time and potentially finding and fixing serious issues before they cause more costly repairs. Digital twins can also better estimate remaining useful life (RUL).

Digital Twin in Action

The electronics division of Leonardo offers a broad range of products for the aerospace and defense industry. To improve predictive maintenance for its Airborne Reconnaissance System, it adopted digital twin technology – it's not your average digital twin solution. "To verify the performance of our radar units in virtual flights, it's fundamental that our digital twin condenses all physics, plus machine learning models based on real-world data, into one single environment," said Romano Iazurlo, chief technology officer, Leonardo Electronics. "Together, we built a process to define where and which sensors to include in our products to benefit from Predictive Maintenance."

Leonardo also adopted a digital twin for assessing antenna-transmission loss of a helicopter radar system that was caused by in-flight vibration to the helicopter's radome. As vibration deformed the radome and antenna within, the antenna's electromagnetic behavior changed. Leonardo needed to capture the changes at the antenna-system level. However, physically measuring the deformation and tracking electromagnetic behavior during flight was impossible. Leonardo needed a solution to predict electromagnetic behavior and optimize the antenna design to meet mission requirements.

Leonardo looked to Altair's digital twin solutions to determine the vibrational impact on the radome and EM signature of the antenna. Using Altair® OptiStruct® for predicting deformation resulting from vibration impacting the antenna, Altair® Feko® for electromagnetic field analysis, and Altair Activate® for comprehensive system simulation, Altair correlated multi-system data to help Leonardo find an ideal radome and antenna design to handle the vibration—all without using a physical prototype.

EMERGING TECH BREW REPORTS HOW ORGANIZATIONS LIKE NIAR ARE DEVELOPING THEIR DIGITAL TWIN TECHNOLOGY WITH ALTAIR.

WHY ALTAIR IS DIFFERENT

Altair is committed to developing the market's premier, open-source, physics-based digital twin solutions. We believe in a convergence of data analytics, machine learning, and code-free options that are delivered with no lock-in to a toolset or vendor. Our capabilities are meant to be flexible, easily accessed, and integrated with other tools so users can collaboratively and rapidly develop customized solutions.

Altair's digital twin solution enables profound cross-functional and enterprise-wide access and collaboration across disciplines with its open and vendor-agnostic simulation, HPC/cloud, and AI/machine learning toolsets.

We're the only company that offers customers the flexibility to run software anywhere—through the cloud, on-premises, or with plug-and-play appliances—and the freedom to choose from comprehensive tools that offer unparalleled value from our cost-effective, unique licensing and business model.

Data can enter and leave our tools and continue to be traced as part of the digital thread. Altair also has a suite of data analytics tools that cover every aspect of enterprise data management. All these tools are accessible under a single-license model that makes it easy to add and remove components to reduce cost and streamline procurement.

Our scalable solutions help you manage exponentially increasing volumes of data across the entire enterprise. By delivering full visibility into key technical performance indicators throughout the product lifecycle, Altair helps accelerate your design, development, and certification process, giving your organization a competitive advantage. Here's a brief look at the tools that Altair offers for building the ideal digital twin for your enterprise:

Altair Activate® is an open and flexible integration platform for comprehensive system-of-systems simulation. Based on a hybrid, block-diagram modeling environment for signal blocks, object-oriented physical components, and electrical and electronic systems, Activate enables multi-disciplinary simulation and optimization across multiple levels of fidelity throughout the development cycle.

Using our partners in the Altair Partner Alliance, XLDyn, engineers can practice MBSE to associate product requirements to verification methods while maintaining traceability and providing real-time status to the project team.

Altair® HyperStudy® offers powerful design exploration and optimization. By using automatic processes combining state-of-the-art mathematical methods, predictive modeling, and data mining, HyperStudy explores the design space of any system model smartly and efficiently. Users are guided to understand data trends, perform trade-off studies, and optimize design performance and reliability while considering multiphysics constraints.

CONCLUSION

Scale and flexibility matter in building out your digital twin program. When choosing vendors, you need to think about how they can help you:

- Break down silos and converge data
- Build a digital twin with flexible, scalable, and open-source components
- Understand how to mix and match cloud and on-prem
- Discover the value of predictive maintenance

Altair is committed to supporting digital twins that meet all these criteria and more.

To learn more, visit altair.com/digital-twin.

Altair is a global leader in computational science and artificial intelligence (AI) that provides software and cloud solutions in simulation, high-performance computing (HPC), data analytics, and AI. Altair enables organizations across all industries to compete more effectively and drive smarter decisions in an increasingly connected world – all while creating a greener, more sustainable future.

For more information, visit www.altair.com