AEROSPACE & DEFENSE

EVTOL: PIONEERING ENERGY-EFFICIENT SKIES

Revolutionize advanced air mobility from concept to certification with the virtual twin experience.

Inceptra

DASSAULT SYSTEMES

A NEW DAWN FOR AEROSPACE

The start of the jet age brought with it a revolution in aircraft design. New players entered the market with bold new concepts, while many established manufacturers struggled. Since then, progress has been gradual and evolutionary. The industry has consolidated around a few major manufacturers with little room for new entrants. Electric aircraft — particularly electric vertical takeoff and landing (eVTOL) — can potentially change that.

Climate goals are one obvious reason there is such great interest in electric flight as it promises big advantages — beyond environmental benefits — over conventional flight. Driven by electric motors, the eVTOL and other types of rotorcraft are cheap to operate and can be maneuvered easily with precision while being quieter than conventional helicopters. This creates a new potential market: Advanced Air Mobility.

Exploring the possibilities in the electric flight race underscores the importance of simulation in resolving the unique problems and challenges of electric flight and eVTOL development. By leveraging simulation, companies can accelerate certification processes, ultimately gaining a competitive edge when entering this new and dynamic market.

Changing the Way We Fly

Changing the way we fly today is imperative to capture the sustainable aviation vision.

> **"Aerospace is about connecting people. As we enable more people to fly conveniently in the future, we need to shift from flying on jet fuel to more sustainable fuel, hydrogen power or electric-powered aircraft,"** says David Ziegler, Vice President of Aerospace & Defense Industry, Dassault Systèmes.

But beyond developing next-generation, alternatively-powered aircraft, Ziegler opines that an effective carbon reduction route also arises from how we operate the aircraft — highlighting the crucial need for efficient energy management systems (EMS) for eVTOL.

Ziegler explains, "95% of greenhouse gas emissions come from how you operate your aircraft. So, if you want to have a meaningful impact, that is where you start. For example, leveraging the right navigation systems and flying information can help you save 20% fuel burn."

Simulating and collaborating on a single unified platform, such as the **3DEXPERIENCE®** platform, can help companies harmonize data, work and methods and explore multiple scenarios to optimize energy management systems in the journey to net-zero skies.

> **"Our virtual twin is vital to explore the combination of real-world data and the full behavior of the system we want to simulate to give us the best outcome,"** adds Ziegler.

In the following pages of this ebook, you will discover:

- Comprehensive solutions related to eVTOL challenges
- End-to-end insights for efficient energy management distribution and flow
- Benefits of model-based certification with the **3DEXPERIENCE** platform

DESIGNING EVTOL FOR PUBLIC ACCEPTANCE

Many factors go into developing an aircraft concept, but public acceptance deserves special attention for advanced air mobility applications. Safe flight in a challenging urban environment, acceptable noise levels and energy efficiency to maximize range and payload are key to winning the public's acceptance of eVTOL. Since gaining public acceptance is a joint responsibility of regulators, creators and operators, overcoming the psychological barrier becomes crucial. The table below shows how simulation can help overcome this challenge.

	CHALLENGES	BENEFITS OF SIMULATION
SAFETY 	Operation in densely populated areas leaves very little room for emergency maneuvers. In case of failure, both passengers onboard and those on the ground are in danger. Tall buildings and structures cause unusual wind conditions and turbulence, which may risk passenger safety. As urban air space continues to be heavily contested, safety becomes paramount.	**Aerodynamic:** Analyze flight dynamics and control in many real-world conditions and understand complex failure cases. **Electromagnetic:** Simulate electromagnetic environmental effects such as lightning, and identify electromagnetic interferences on electrical and communication systems. **Structural:** Model bird, drone strike and hard landing.
NOISE 	eVTOLs will have to be much quieter than other rotorcraft — not only to be certified but also accepted by communities by blending into the background noise. The passenger experience also plays a significant role in public acceptance. The cabin will have to be quiet and comfortable.	**Aeroacoustic/vibroacoustic:** Design rotors and other components to reduce the noise produced and blend in the city's background noise. Improve passenger experience in the cabin by reducing cabin noise.
EFFICIENCY 	eVTOLs will generate complex interactional aerodynamics and large flow separations, leading to energy losses. This demands the most optimized design to maximize the battery's limited energy density. Additionally, batteries will operate at best within a certain range of temperature. Proper cooling management will be central to maximizing the battery efficiency and life while minimizing the parasitic drag generated.	**Structural**: Reduce weight while maintaining strength. **Electromagnetic**: Optimize motors. **Aerodynamic**: Minimize drag and optimize rotors.

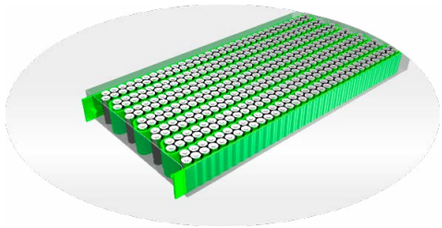
WHY EFFICIENT EMS MATTER

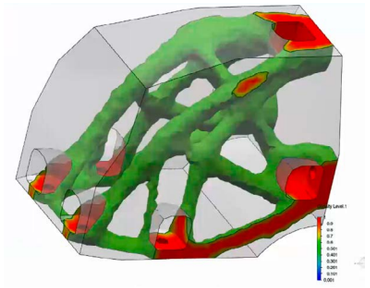
To achieve energy efficiency in electric-powered eVTOLs, careful **energy distribution, use and storage** are paramount. An efficient EMS helps integrate, simulate and improve energy consumption in eVTOLs. Optimal energy consumption predictions ensure that eVTOLs complete their flights safely and optimally. Additionally, the right EMS will sustain sufficient energy reserves to conduct **fast power responses** seamlessly for safe and optimal take-off, climbing and landing maneuvers. Smart overall energy distribution in the eVTOL will also **extend the battery life and fuel cells** to optimize efficiency, boost reliability and reduce carbon footprint and cost.

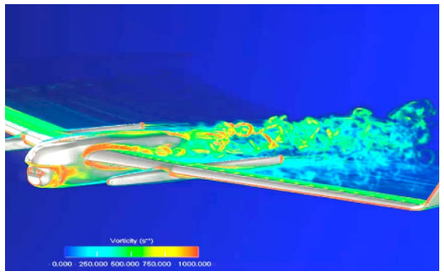
However, many significant challenges hinder the realization of energy-efficient eVTOLs. From wind turbulence to design and engineering complexities, expensive prototyping and lengthy certification processes, these hurdles must be tackled through advanced simulation capabilities that harness data analytics and end-to-end multidisciplinary integration.

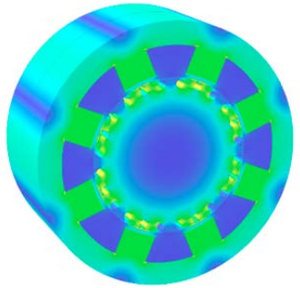
Dassault Systèmes' comprehensive solutions, such as CATIA, SIMULIA and the leading industry solution experience, Reinvent the Sky, enable companies to optimize energy efficiencies under eVTOL constraints. This strategy reduces carbon emissions and empowers companies to virtually address and mitigate potential issues before they become formidable barriers to progress.

Here is an example. Electric flight pushes the very limits of what modern batteries are capable of. With range constrained by the energy that can be stored on board, even small energy savings can go a long way to making an electric aircraft concept more viable. Using simulation, engineers can optimize their designs across many different parameters to shed excess weight, minimize drag, improve motors and get more out of battery packs through proper cooling management — while minimizing the parasitic drag from cooling vents.









BATTERY PACKS

Challenge

Maximizing energy density while maintaining safety and performance.

Solution

A comprehensive battery workflow and complete simulation solution lets designers improve chemistry, thermal performance and structural strength to increase capacity safely.

LIGHTWEIGHTING

Challenge

Minimizing the weight of components without compromising strength.

Solution

Remove unnecessary material while still meeting strength requirements and reducing component weight.

AERODYNAMICS

Challenge

Understanding the aerodynamics of a design from the very start.

Solution

The virtual twin approach replicates a physical wind tunnel on a simulated model.

MOTORS

Challenge

Designing motors powerful enough to generate lift but lightweight and energy efficient.

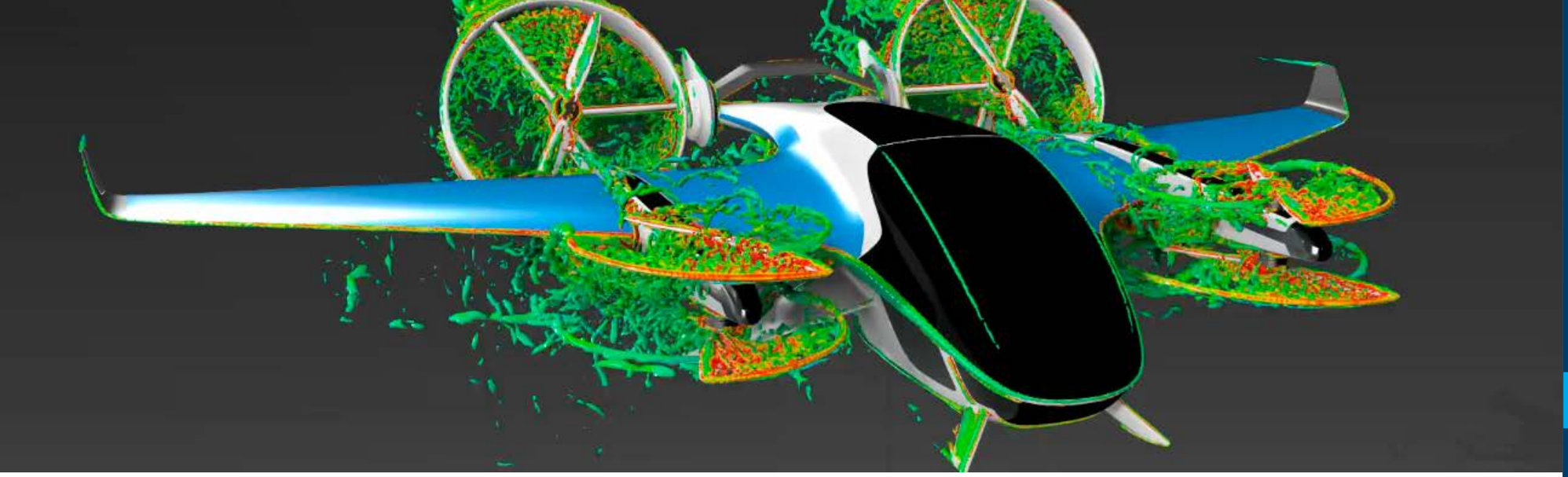
Solution

Optimize coil and magnet placement to minimize power consumption and maximize torque.

ENERGY-EFFICIENT ENGINEERING DESIGNS

eVTOL designs are revolutionary compared to aircraft designs. These uber-cool shapes of an eVTOL play heavily in aerodynamic design.

Many eVTOL start-ups have selected the **3DEXPERIENCE** platform to accelerate conceptual design with seamless integration of design and multiphysics systems and performance optimization.



Aerodynamic advancements

The flight dynamics for electric aircraft can be very different from those of conventional airplanes. Batteries and motors give a different weight distribution to fuel tanks and turbofans. The flight patterns of eVTOL, impacted by multiple rotors tilted to different configurations (see image above), are even more complex to analyze.

Sudden gusts, wind reflected from the ground and nearby buildings, and turbulence and wake from other passing aircraft also affect aerodynamics. Even the simplest case — cruise condition at low angle of attack — can be challenging to model with conventional CFD since a lot of flow separation will happen due to the complexity of the geometry.

These off-design flight conditions are usually not optimized during development. The crash of a prototype during testing due to off-design effects is a danger to employees and bystanders. Even if no injuries occur, an expensive prototype has been lost, as have investors' confidence and potential customers.

Advanced simulation like SIMULIA PowerFLOW can narrow the gap between on-design and off-design. Real-world scenarios that could never be tested in the wind tunnel can be modeled virtually — and safely — to meet requirements for the full flight envelope. Engineers can understand and mitigate dynamic loads during critical flight conditions, increase certification confidence and reduce dangerous physical tests.

Structural Improvements

The **3DEXPERIENCE** platform's integration of CATIA's high-end CAD functionality and the proven simulation technology from SIMULIA has resulted in a shift in the design paradigm. Instead of simply checking if a design meets requirements, we can now use technology to find the design that best meets the requirements, resulting in highly optimized lightweight structures.

However, achieving structural optimization while minimizing weight and maintaining safety is complex. It requires exploring thousands of structural design alternatives to answer various crucial questions, such as:

- How to optimize dynamic characteristics to ensure the structural integrity of battery modules? *(Structural integrity of the battery cell is assessed using virtual compression, three-point bending and impact tests)*
- What is the ideal architecture to provide the right overall energy distribution?
- What is the battery layout impact on aircraft maneuverability?

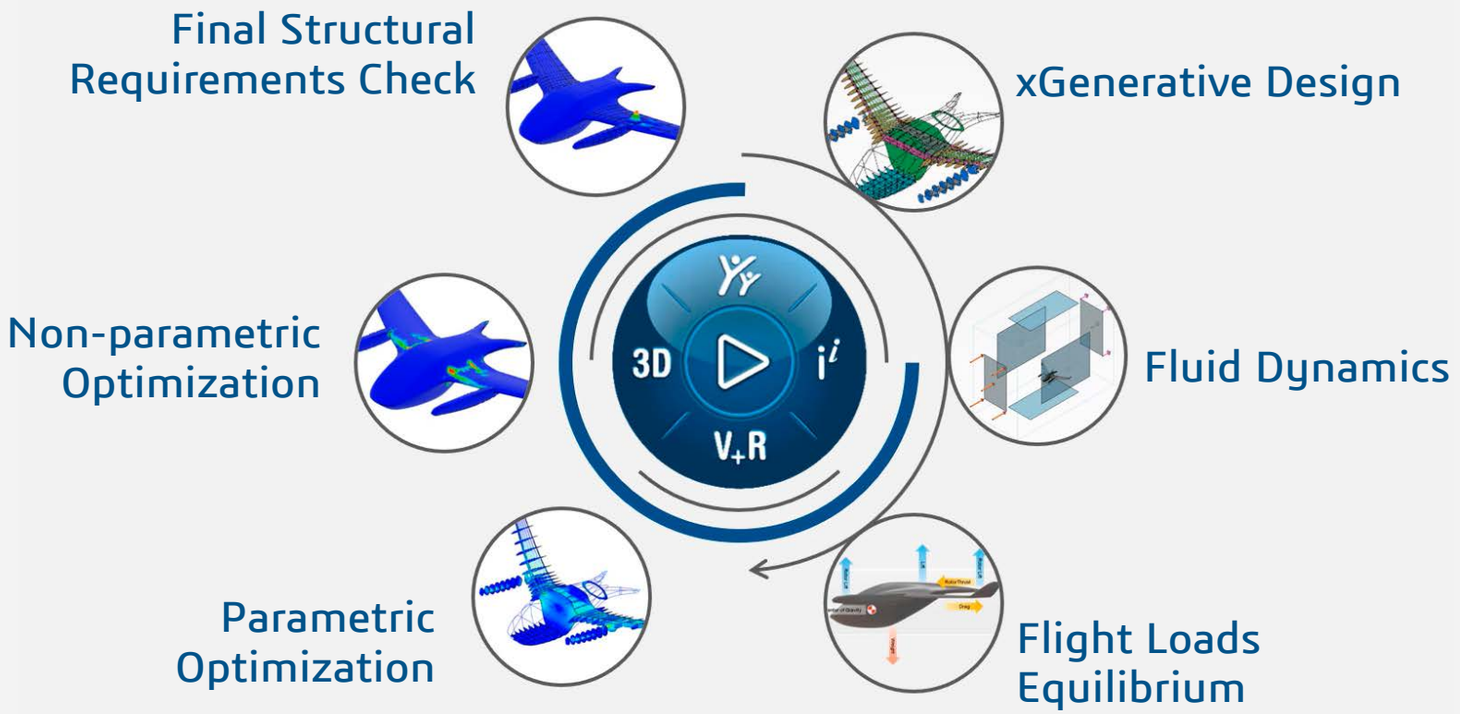
Dassault Systèmes' solutions help companies to streamline optimal structures quickly and accurately. This approach keeps structural integrity and, in some cases, reduces eVTOL weight by as much as 35%[1] to surpass any aircraft weight standards.

[1] Dassault Systèmes Blog: VTOL: Batteries, Hydrogen Fuel Cells or Hybrid Energy

THE VIRTUAL TWIN ADVANTAGE

Simulation can supplement measurement — and even sometimes replace it. This saves the money and development time needed to build and test several rounds of prototypes. Simulation, however, is only possible if you have a model that accurately represents reality.

The virtual twin approach builds a digital model of the product, which includes all the relevant data — such as design requirements, model geometry, assembly, simulation and measurement data. The virtual twin contains enough information to model real-world behavior accurately. The following diagram shows how the virtual twin perfectly balances the design requirements and needs.



MODEL-BASED CERTIFICATION

Certifying aviation products requires a high level of rigor that significantly raises the cost and duration of development programs. This activity, which connects the type of certification applicant to the authority, traditionally involves large quantities of paper or electronic document exchanges through numerous emails and meetings. As such, major digital discontinuities exist between the applicant and the authority and from within the applicant's own organization, in the airworthiness office and among the rest of the organization. These digital discontinuities make it extremely challenging for the certification process to keep pace with the product definition. There will be hundreds, if not thousands, of design changes between the initial design configuration and the final one corresponding to the type definition. Not only does this hinder the development pace, but it also generates a risk of discovering late-stage certification issues that will require additional design changes or testing — further delaying entry into service. Finally, the means of compliance still heavily rely on large and costly physical test campaigns that sit on the program's critical path.

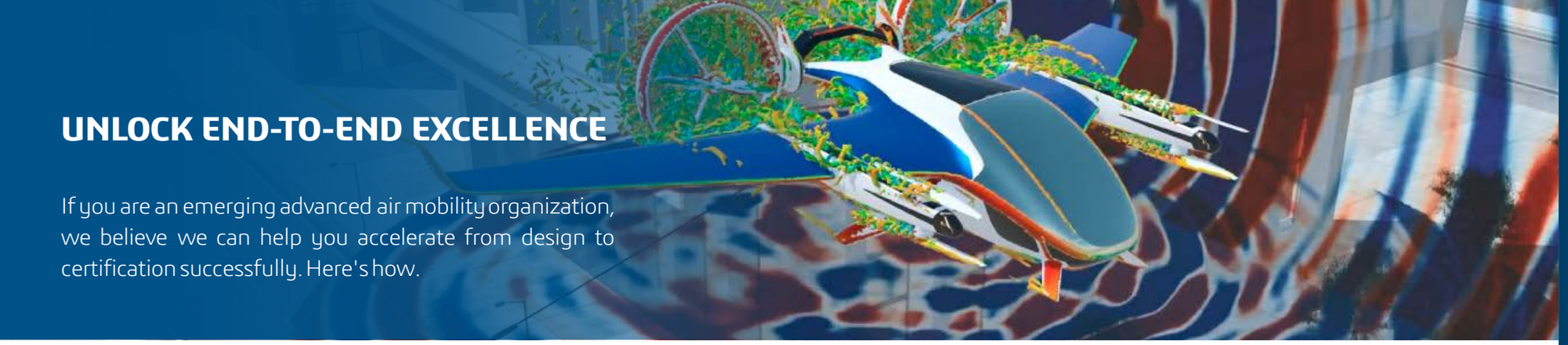
As the eVTOL market becomes increasingly competitive, staying ahead demands adopting a model-based certification approach. This approach can streamline regulatory compliance, expedite approval processes and ensure more rapid integration of innovative technologies to outpace competitors. Here are the four distinct features of model-based certification powered by the **3D**EXPERIENCE platform.

> "The **3D**EXPERIENCE platform will help us to develop and share the critical steps of requirements, ensure we're developing the aircraft according to those requirements, do validation and also manage the certification of the aircraft with the authorities. It's a one-stop shop and single source of truth for Vertical Aerospace and our business partners that allows us to work concurrently wherever we are in the world.
>
> —Eric Samson, Head of Engineering, Vertical Aerospace

Our Game Changers

Integrate Airworthiness and Design Processes	Ensure Consistent Engineering Process Rigor	Incorporate Full Envelope Virtual Testing	Integrate Management of V+R Testing
• A unified environment to streamline collaboration between the airworthiness office and design office • Accelerated certification process leveraging model-based systems engineering framework to cascade regulatory requirements down to product and systems levels • Digitalized regulations and industry standards corpus to accurately compose certification basis and means of compliance • Type certification intelligence analytics to reveal certification know-how from past projects	• Unified data model for a single source of truth • Transverse configuration management and change process to manage type definition and design baselines • Guided business process and model and notation (BPMN) workflows, ensuring the level of rigor expected by regulators • End-to-end traceability provided natively by **3D**EXPERIENCE apps, avoiding error-prone manual after-the-fact approach • Report generation from model-based data to produce records efficiently	• Portfolio of high-fidelity multi-scale simulation technologies to address the entire operational envelope • Innovative structures, fluids, acoustics, thermal, electromagnetics, systems and software disciplines • Native or connected to the platform to accelerate the ModSim loop • Built-in simulation process and data management to capitalize knowledge and standardize methods	• A unified approach to managing virtual and physical tests for better synergy • Simulation credibility framework to perform model accreditation for intended purpose and criticality level • Verification and validation (V&V) tiered strategy to be optimized according to system criticality and means of compliance cost • Integrated V&V schedule to monitor execution and synchronize all stakeholders • One test intelligence to efficiently retrieve virtual and physical test results in context and maximize reuse

Companies rely on model-based certification to accelerate verification, ensure regulatory compliance, enhance safety and protect profits at every product lifecycle stage. **As a result, they get more innovative products to the market faster and secure market leadership.**



UNLOCK END-TO-END EXCELLENCE

If you are an emerging advanced air mobility organization, we believe we can help you accelerate from design to certification successfully. Here's how.

Reliable Design

State-of-art Navier-stokes CFD solver is efficient, accurate, and robust for solving complex aerodynamics problems.

Optimal Design

With simulation, engineers can optimize and trade off factors including weight, power, energy consumption, noise, drag and experience.

Collaborative Design

3DEXPERIENCE platform allows free sharing of data to different stakeholders both internal and external to the organization while maintaining control of who can access which information.

$€¥ Reduce Cost

Vehicle aerodynamic results are analyzed and shared early in the design process to reduce risk and avoid costly redesigns.

Reduce Time

To reduce the product development cycle, leading companies are relying on science-based modeling and simulation (MODSIM).

Get Certified

A digital thread from requirements to demonstrating the results through simulation will be the key for digital certification and compliance.

In conclusion, an integrated, collaborative approach is indispensable for certification success.

Dassault Systèmes'virtual twin experience and complete suite of solutions can help you simulate contingencies, monitor virtual energy dynamics and assess simulated performance to create a secure journey, optimize energy consumption and respond with agility to unforeseen challenges.

Inceptra

Inceptra supports engineering and manufacturing organizations with best-in-class solutions to digitally design, simulate, produce, and manage their products and processes, enabling enhanced innovation and productivity.

As the largest Platinum partner in North America, Inceptra is dedicated to Dassault Systèmes' product development software portfolio, complementary solutions, and related services, including training, implementation, integration, support, consulting, and automation services. For more information, please visit Inceptra.com.

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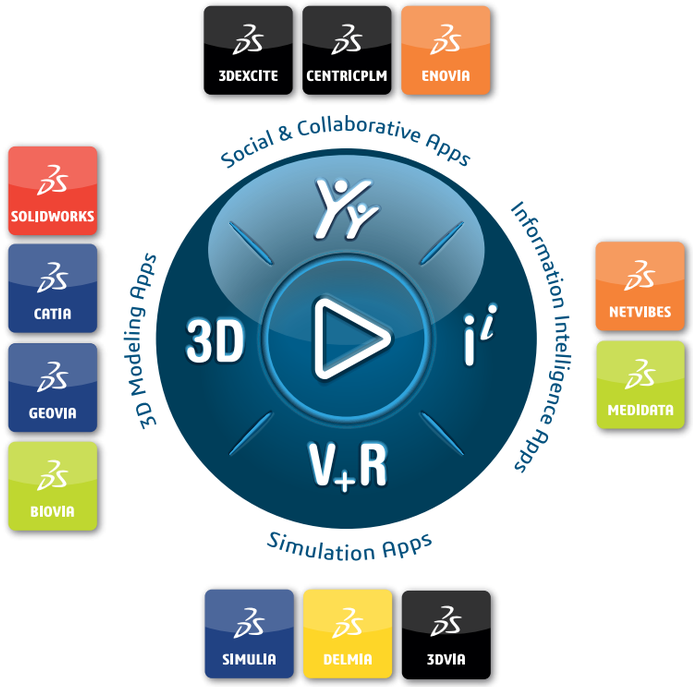
Our **3D**EXPERIENCE® platform powers our brand applications, serving 12 industries, and provides a rich portfolio of industry solution experiences.

Dassault Systèmes, the **3D**EXPERIENCE Company, is a catalyst for human progress. We provide business and people with collaborative virtual environments to imagine sustainable innovations. By creating virtual twin experiences of the real world with our **3D**EXPERIENCE platform and applications, our customers can redefine the creation, production and life-cycle-management processes of their offer and thus have a meaningful impact to make the world more sustainable. The beauty of the Experience Economy is that it is a human-centered economy for the benefit of all –consumers, patients and citizens.

Dassault Systèmes brings value to more than 300,000 customers of all sizes, in all industries, in more than 150 countries. For more information, visit **3ds.com**.



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