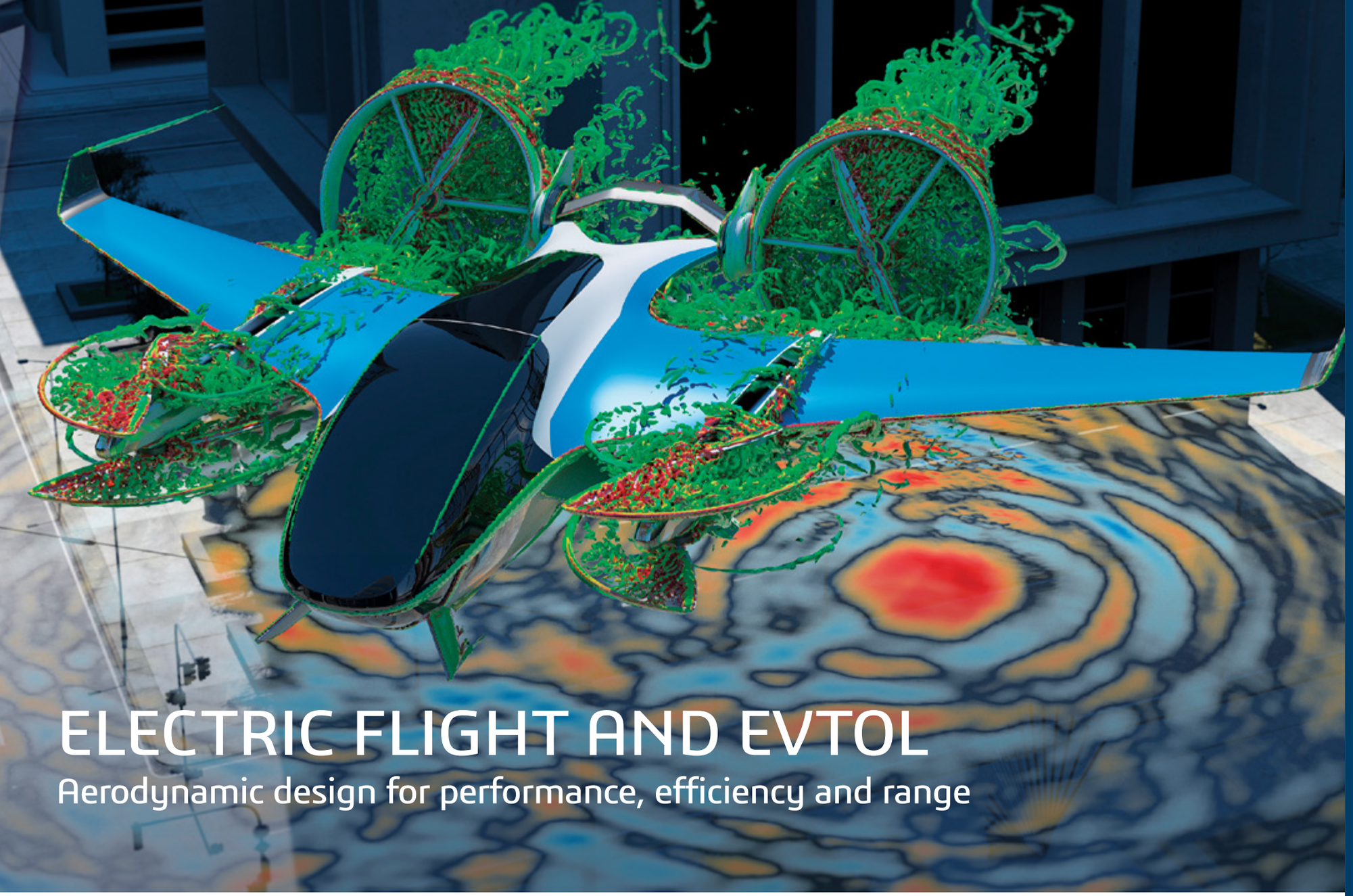


ELECTRIC FLIGHT AND EVTOL

Aerodynamic design for performance, efficiency and range

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 and the industry has consolidated around a few major manufacturers with little room for new entrants. Electric aircraft—and particularly electric vertical takeoff and landing (eVTOL)—have the potential to change that.

Climate goals are one obvious reason why there is such great interest in electric flight, but it promises big advantages over conventional flight even beyond its environmental benefits. Driven by electric motors, eVTOL and other types of rotorcraft are cheap to operate and can maneuver precisely while being quieter than conventional helicopters. This creates an entirely new potential market: advanced urban and regional air mobility.

This ebook will cover the possibilities and the challenges of the race to electric flight. Simulation can help solve the unique problems of electric flight and eVTOL development, and give companies a competitive edge when entering this new and dynamic market.

While the ebook illustrates the challenges and solutions pertaining to eVTOL, there are other players who may face similar problems.

Electric flight by propulsion:

- Electric planes
- Solar aircraft

Electric flight by applications:

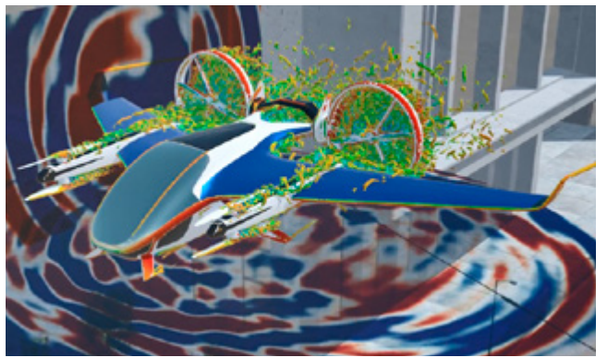
- Urban and regional air mobility (“air taxis”)
- Drones and cargo aircraft

DESIGNING EVTOL FOR PUBLIC ACCEPTANCE

There are many factors that go into developing an aircraft concept, but for urban air mobility applications, public acceptance deserves special attention. Safe flight in a challenging urban environment, acceptable noise levels, and energy efficiency to maximize range and payload are key to winning the public acceptance of eVTOL. It's also a joint responsibility of regulators, creators, and operators. In the table below see how simulation can help overcome this psychological barrier.

	CHALLENGES	BENEFITS OF SIMULATION
SAFETY 	Operation in densely populated areas leaves very little room for emergency maneuvers; in case of accidents, both passengers/ cargo onboard and those on the ground are in danger. Tall buildings and structures cause unusual wind conditions—the passengers must feel safe and stable even in turbulence—while urban air space is heavily contested.	**Aerodynamic**: analyze flight dynamics and control in many real word conditions and understand complex failure cases. **Electromagnetic**: simulate lightning, radar and interference. **Structural**: model bird/drone strike.
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 large 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 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 and will need the most optimized design to make the most of the battery's limited energy density. Additionally, batteries will operate at best within a certain range of temperature and proper cooling management will be central to maximize 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.

SAFE FLIGHT

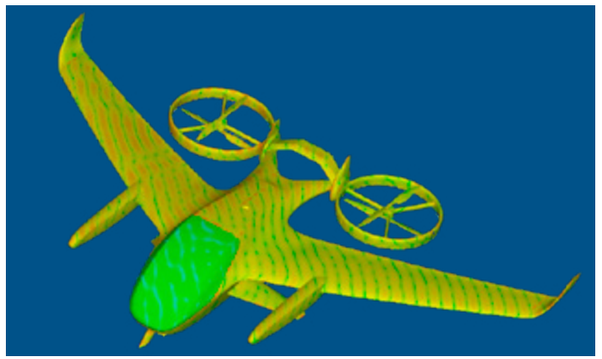


Air flow on a city street

Challenge
eVTOL air taxis will operate in city environments with turbulence and will need to be able to fly safely in gusts while being energy efficient and quiet.

Solution
Aerodynamic simulation can model and visualize air flow in realistic environments, allowing engineers to understand flight dynamics in complex scenarios.

Product
SIMULIA PowerFLOW

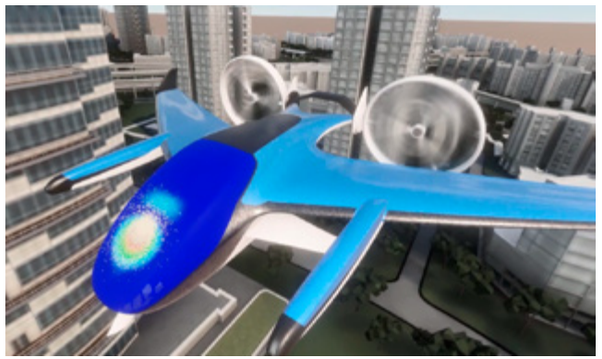


Surface currents induced by HIRF

Challenge
Lightning and high-intensity radio frequency (HIRF) can affect on-board electrical and electronic systems.

Solution
Electromagnetic simulation identifies potential interference risks and helps engineers successfully mitigate them.

Product
SIMULIA CST Studio Suite



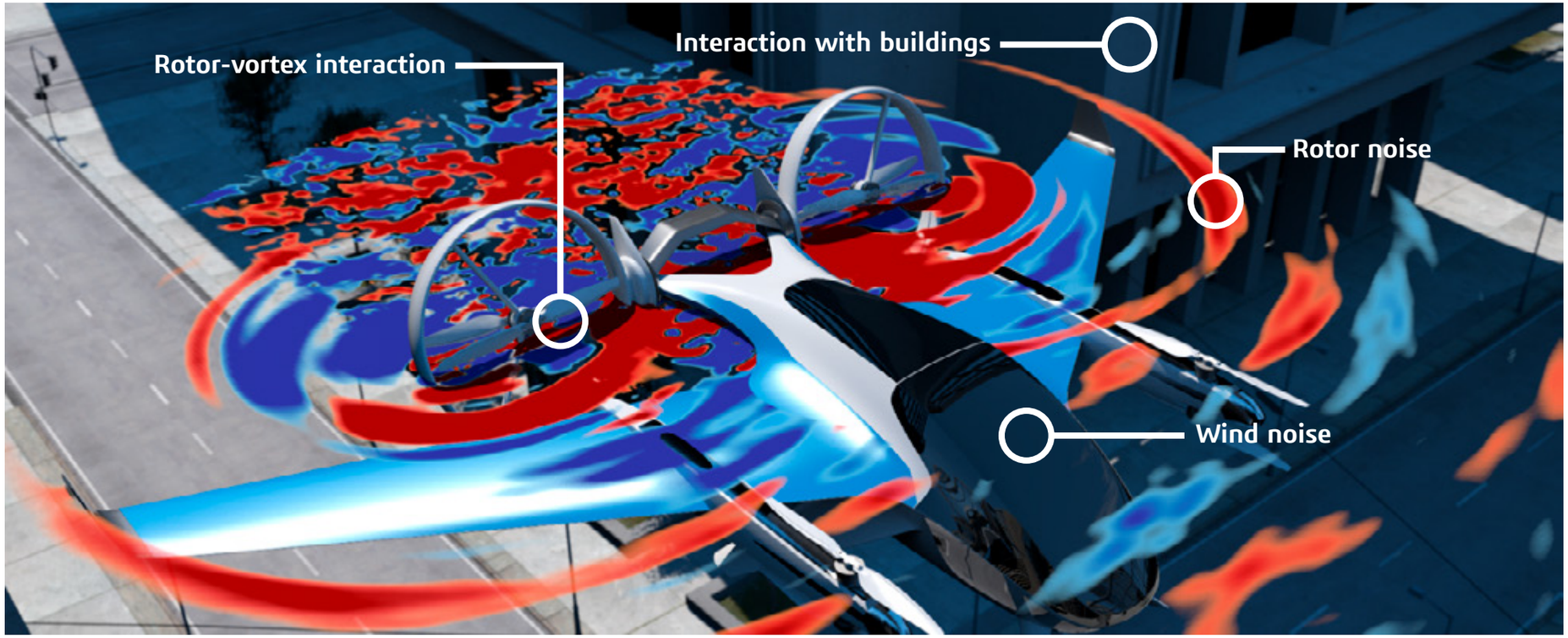
Impact with a moving body against the cockpit

Challenge
eVTOL needs lightweight and novel design concepts, such as carbon-fiber monocoque. These new materials and designs need to be assessed for strength, especially in collisions with objects such as birds and drones.

Solution
Structural simulation models the impact and the resulting forces and stresses to ensure that the aircraft maintains its integrity.

Product
SIMULIA Abaqus

NOISE



Potential noise sources on an eVTOL aircraft

Challenge

An eVTOL will generate noise. To be accepted by a community and be certified, its noise footprint will have to be unobstrusive. Broadband interactional noise will have to be taken in consideration early in the design phase to be sure and the vehicle will be designed around one goal: blend into the city background noise. Additionally, during transitions, the vehicle will be prone to Blade Vortex Interactions (BVI) and in cities there is turbulence and wind flow recirculation around buildings which will increase its noise footprint.

Solution

With aeroacoustic simulation, the user can:

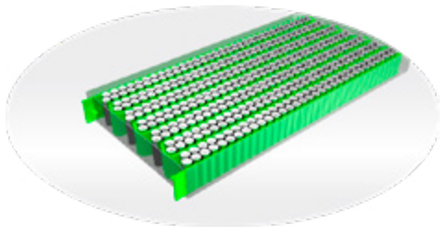
- Predict all the noise sources and its mechanisms
- Account for realistic atmospheric and ground topology effects
- Predict exactly how the vehicle will be perceived in urban environments

Product

SIMULIA PowerFLOW

ENERGY EFFICIENCY

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 in order 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

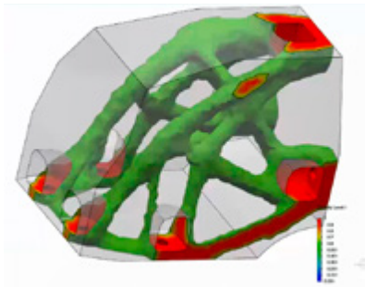
Maximizing energy density while maintaining safety and performance.

Solution

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

Product

Dassault Systèmes provides a comprehensive battery workflow.



LIGHTWEIGHTING

Challenge

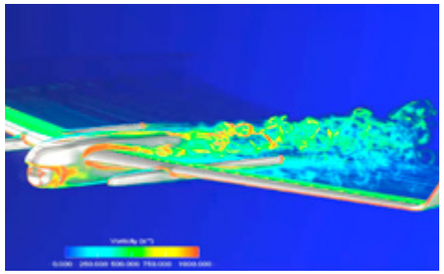
Minimizing the weight of components without comprising strength.

Solution

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

Product

SIMULIA Tosca



AERODYNAMICS

Challenge

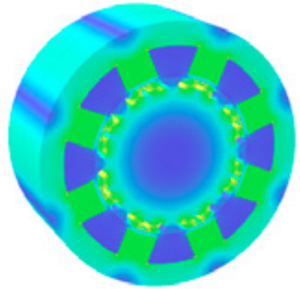
Understand the aerodynamics of a design from the very start.

Solution

The "Virtual Twin" approach replicates physical wind tunnel on a simulated model.

Product

SIMULIA PowerFLOW



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.

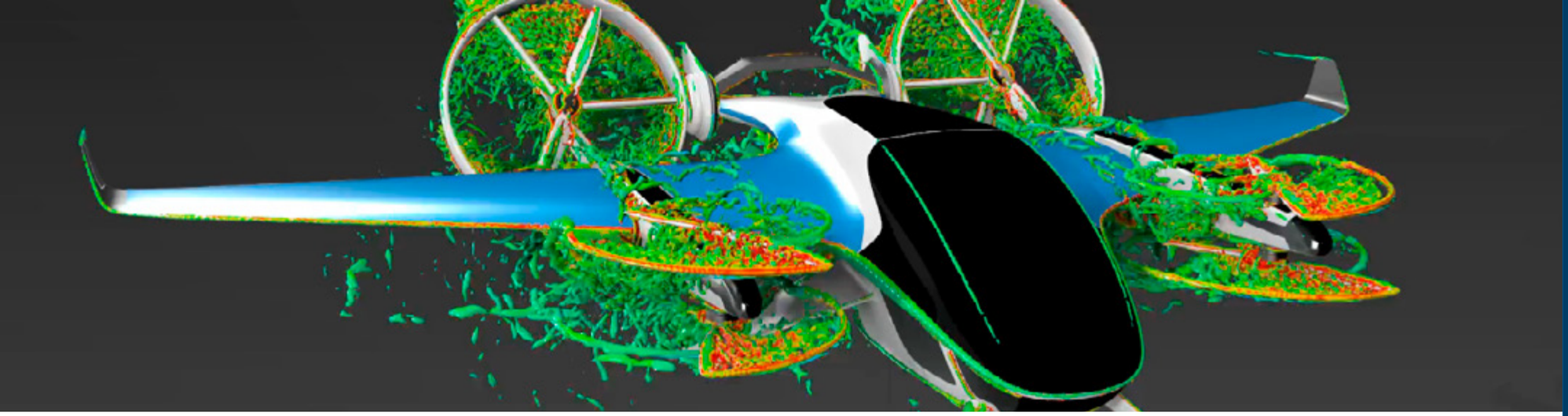
Product

SIMULIA CST Studio and SIMULIA Simpack

OPTIMAL EVTOL DESIGN

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

eVTOL start-ups have selected the **3D**EXPERIENCE® platform to accelerate conceptual design with seamless integration of design, multiphysics and optimization.



AERODYNAMICS OFF-DESIGN

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

Sudden gusts, wind reflected from the ground and nearby buildings, and turbulence and wake from other passing aircraft all 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.

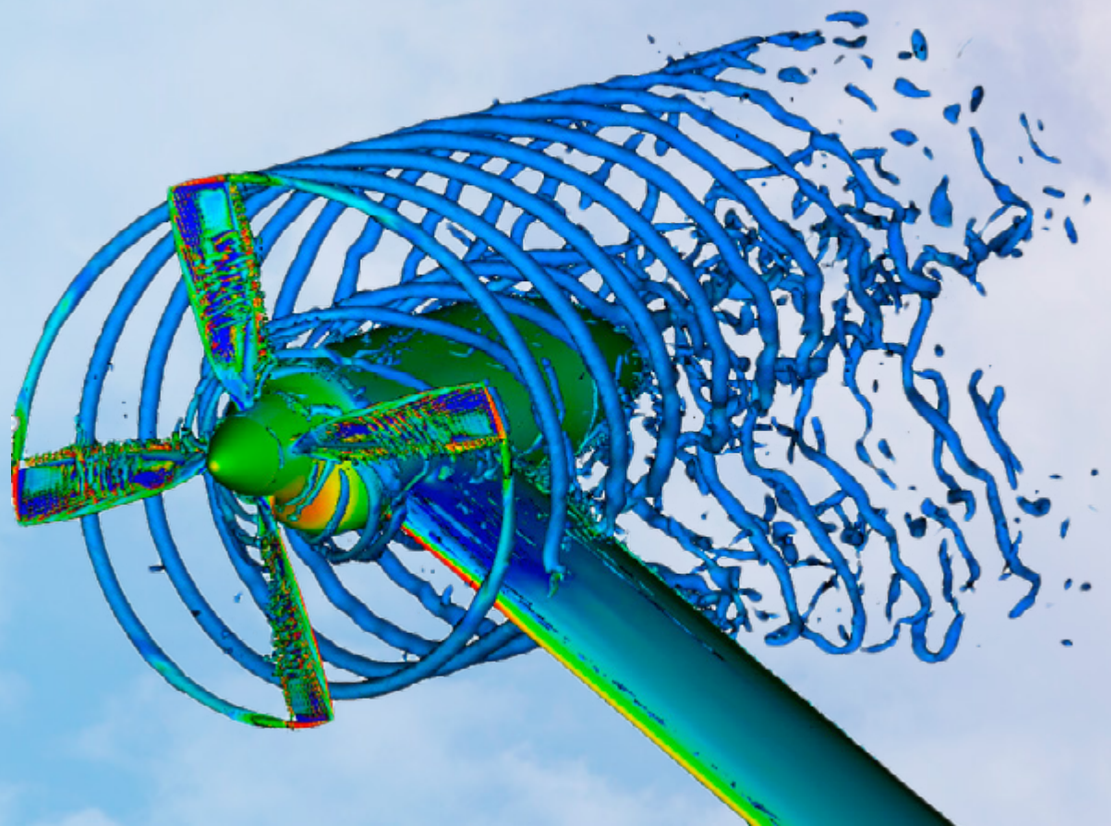
These "off-design" flight conditions cannot usually be optimized for during development. The crash of a prototype during testing due to off-design effects is danger to employees and bystanders—even if no injuries occur, an expensive prototype has been lost, as have investors and potential customers.

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 and increase certification confidence and reduce dangerous physical tests

PROPELLER & AIRFRAME INTERACTION

Distributed electric propulsion—multiple independently driven and controlled rotors—will be the key enabling technology for eVTOL success. First, it removes the single-point failure of a helicopter's main rotor. Increasing the safety of the vehicle by design. Second, by strategically placing the propulsion systems around the vehicle, complex aerodynamic flow features can be harnessed to increase the lift and reduce the drag. Finally, load alleviation will cycle back to a lighter, less draggy airframe.

Aerodynamic interaction between these propellers and airframe can be accurately predicted with the Navier-Stokes CFD solution available in the **3D**EXPERIENCE platform.

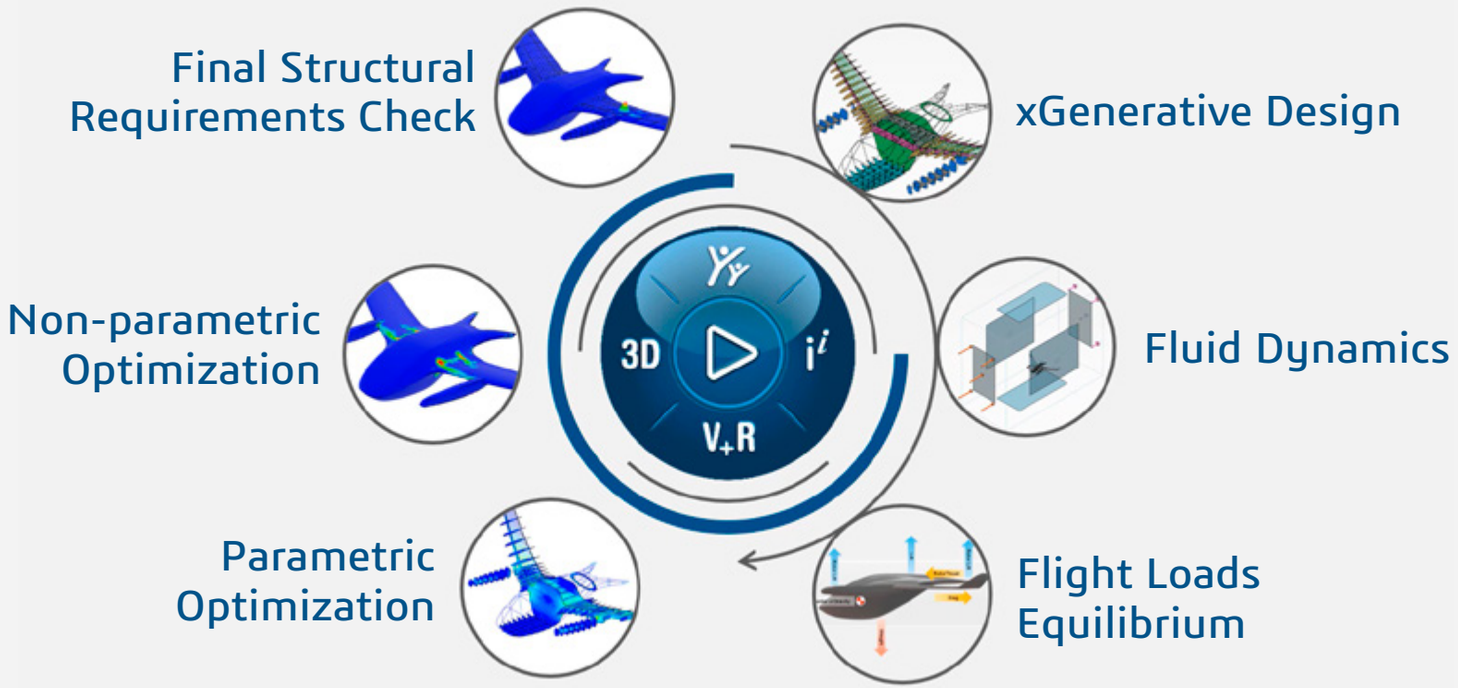


VIRTUAL TWIN EXPERIENCE AND DIGITAL CERTIFICATION

Simulation can supplement measurement—and even sometimes replace it. This saves the money and development time that would be needed to build and test several rounds of prototypes. This is only possible however 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 accurately model the real world behavior.

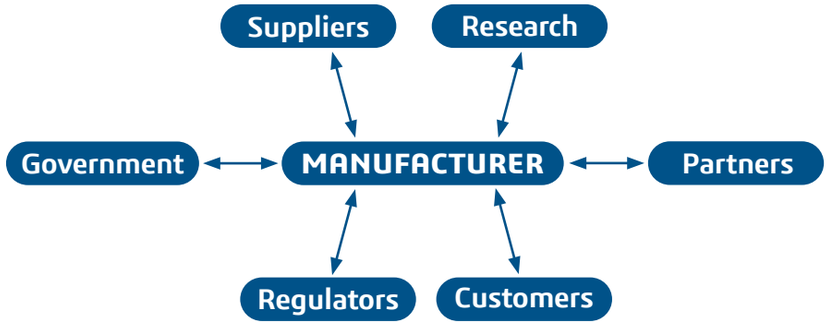
Regulators have even begun talking about digital certification, replacing some physical prototypes and test flights with virtual simulation. This is especially useful for electric flight engineers who are developing aircraft radically different from existing design—they can accelerate the certification process and be more confident that their aircraft will pass testing.



3DEXPERIENCE PLATFORM & MODSIM

The development of any aircraft brings together many fields of engineering, from aeronautics to electronics, and involves numerous stakeholders (see diagram).

The **3D**EXPERIENCE platform brings together Dassault Systèmes products, including both design and simulation tools, in one place. A centralized data repository acts as a single source of truth for all design data while maintaining control of who can access which information.



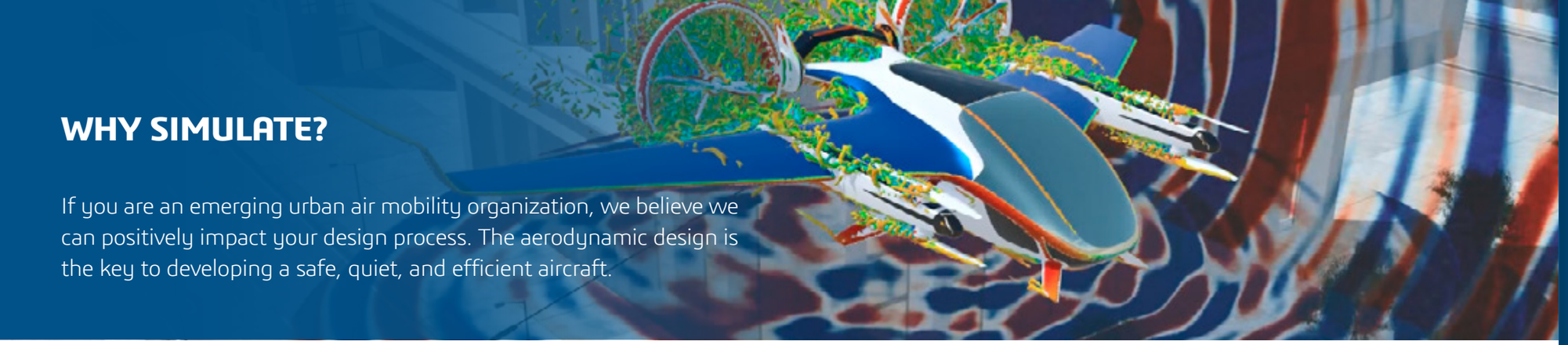
Information flows in electric aircraft development

> **The 3DEXPERIENCE 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

To shorten time to market, deal with complexity, and achieve a competitive advantage, companies are relying on science-based modeling and simulation (MODSIM) at all stages of the product lifecycle from product requirement to design and manufacturing to in-use scenarios. As a result, they require less real-world prototyping and enjoy faster physical certification testing—ultimately getting more innovative products to market faster.

MODSIM is an integral part of the capabilities delivered by the **3D**EXPERIENCE platform.

> **The platform brings all teams together and means that non-CAD people can see the data too.**
>
> —John Russell, Senior Design Engineer, Vertical Aerospace



WHY SIMULATE?

If you are an emerging urban air mobility organization, we believe we can positively impact your design process. The aerodynamic design is the key to developing a safe, quiet, and efficient aircraft.

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.

Inceptra

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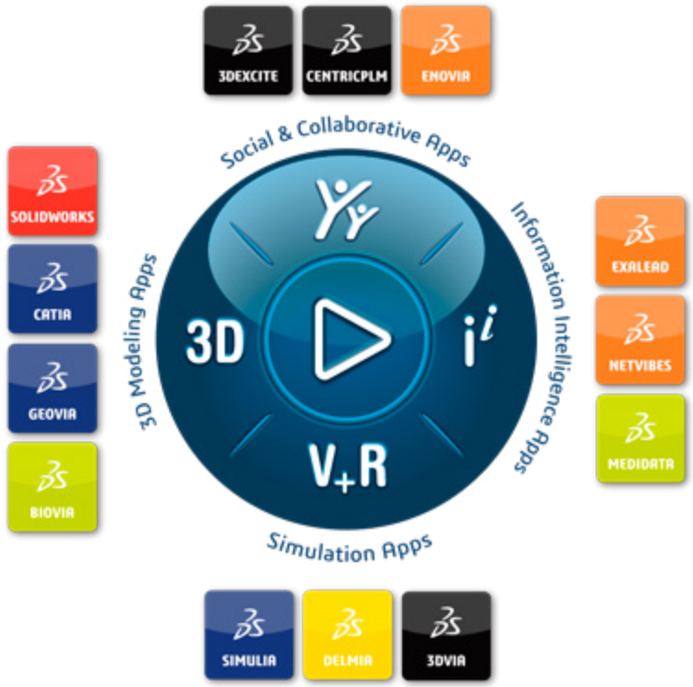
Our **3D**EXPERIENCE® platform powers our brand applications, serving 11 industries, and provides a rich portfolio of industry solution experiences.



Dassault Systèmes, the **3DEXPERIENCE** Company, is a catalyst for human progress. We provide business and people with collaborative virtual environments to imagine sustainable innovations. By creating 'virtual experience twins' of the real world with our **3DEXPERIENCE** platform and applications, our customers push the boundaries of innovation, learning and production.

Dassault Systèmes' 20,000 employees are bringing value to more than 270,000 customers of all sizes, in all industries, in more than 140 countries. For more information, visit **3ds.com**.

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