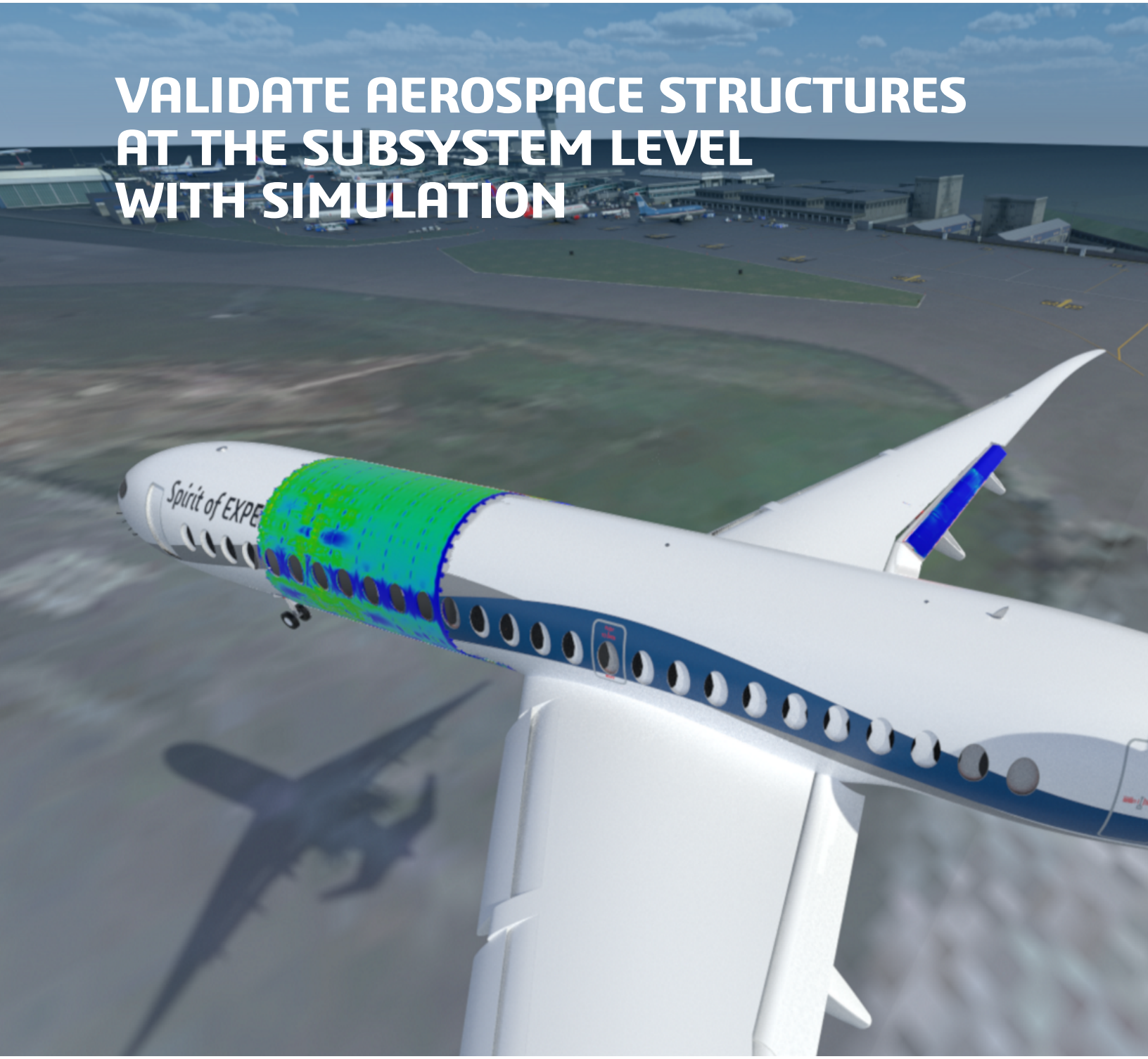
SIMULIA

3DEXPERIENCE®

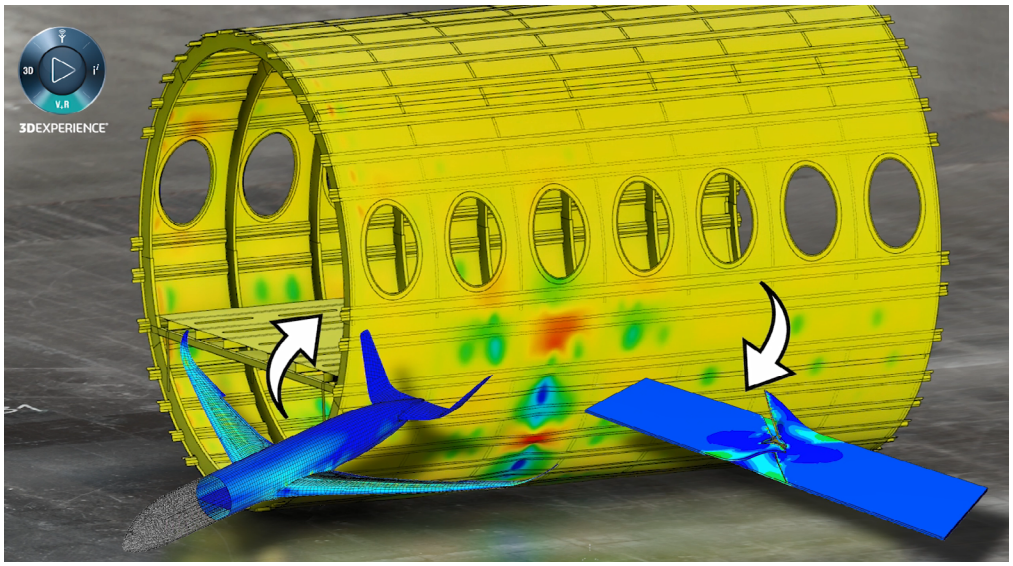
VALIDATE AEROSPACE STRUCTURES AT THE SUBSYSTEM LEVEL WITH SIMULATION



DASSAULT SYSTEMES

The many subsystems that make up an aircraft are themselves made up of numerous components. All this complexity makes analyzing the strength and structural integrity of airframes and aircraft subsystems a major challenge. Components need to meet certification requirements in terms of strength and deformation, damage tolerance, and durability.

To efficiently address these engineering objectives, highly accurate methods for structural validation fully integrated with design are needed in all phases of an aircraft program. Dassault Systèmes' solution, available on the **3D**EXPERIENCE® platform, contributes to increasing certification confidence in early design phases while reducing development time and cost. This solution is based on best-in-class Abaqus solver technology and offers scalable fidelity structural methodologies from linear to highly nonlinear simulations. Substructuring and submodeling techniques are available for transferring load information from the full structure level down to lower levels. Furthermore, unique fracture mechanics capabilities enable the damage tolerance behavior to be analyzed.



Simulation based validation at different structural levels – from the full-scale structure down to coupon level

STRUCTURAL VALIDATION REQUIREMENTS[1, 2]

Thin-walled aerospace structures are susceptible to a variety of failure modes: fracture due to static or dynamic overload, buckling, fatigue, creep etc. Structural validation requires demonstrating that none of these modes leads to failure for any critical loading condition. For commercial aircraft, regulatory requirements for structural validation are issued by the Federal Aviation Administration (FAA) in 14 CFR Part 25, Subpart C and by the European Aviation Safety Agency (EASA) in EASA CS-25, Subpart C. To prove that these requirements are met, physical and simulation based validation is usually performed at different structural levels – from the full-scale structure down to coupon level.

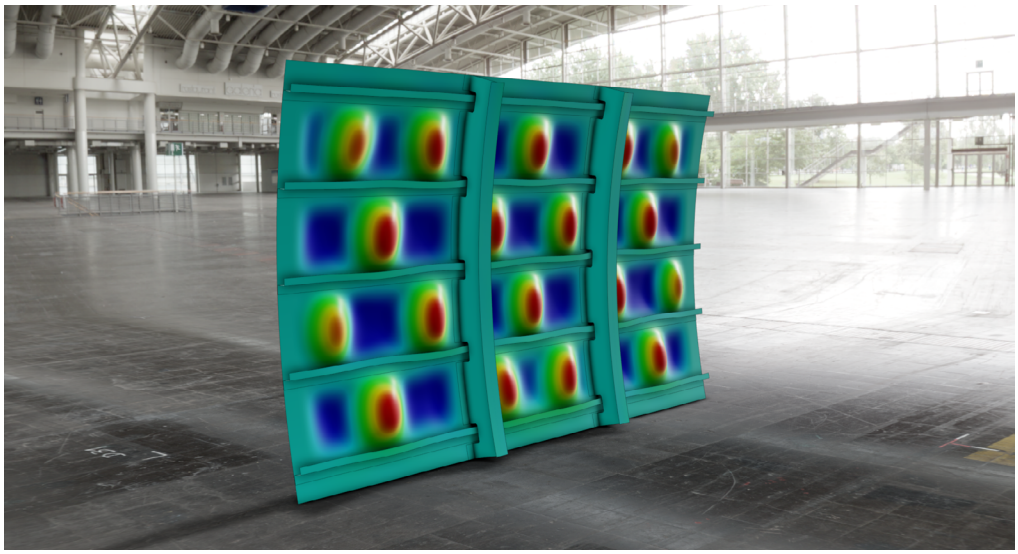
High profile delays and groundings of aircraft in recent years have emphasized the importance of ensuring that aircraft can meet regulatory guidelines as early as possible in the design phase. The shift to lightweight composite materials has made this task more challenging, with complex material behaviors and new failure modes.

[1] Federal Aviation Administration (FAA), Title 14 Chapter I Subchapter C Part 25—Airworthiness Standards: Transport Category Airplanes

[2] European Aviation Safety Agency (EASA), CS-25 Certification Specifications and Acceptable Means of Compliance for Large Aeroplanes

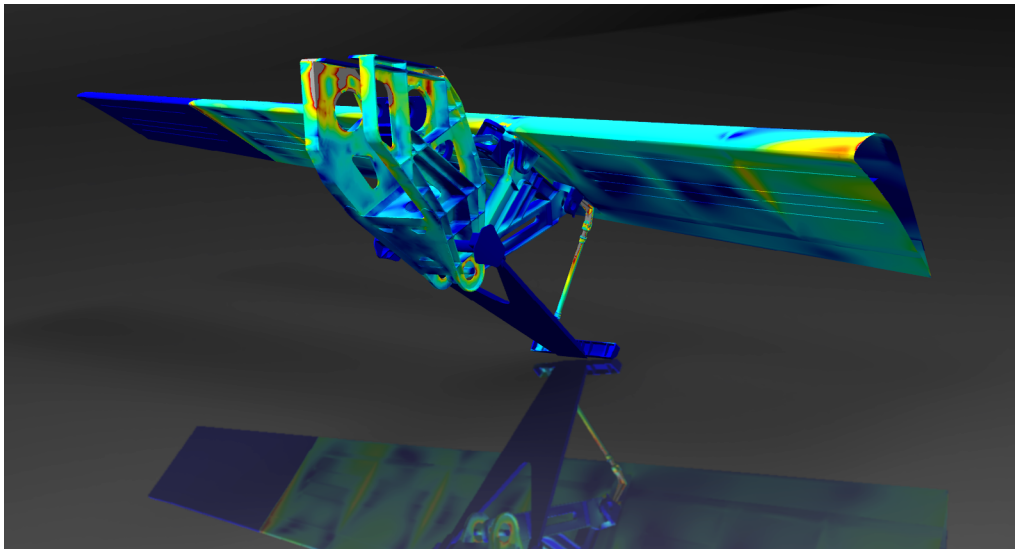
THE SIMULIA SOLUTION

Dassault Systèmes' software offers simulation based solutions for all aspects of structural validation that need to be addressed during design and certification: static and dynamic strength, damage tolerance and durability. Static strength of materials within subsystems is a fundamental requirement to be validated. Both metal structures and composites, such as carbon fiber reinforced plastics, are supported and complex connections between components can be accurately modeled to build up subsystems. Simulation, either on the workstation or in the cloud, can then be used to calculate stress, strain, deflections and failure indices or to determine buckling and collapse loads. For composite materials, which have a complex internal structure, critical values are provided for all plies in order to calculate the margins of safety.



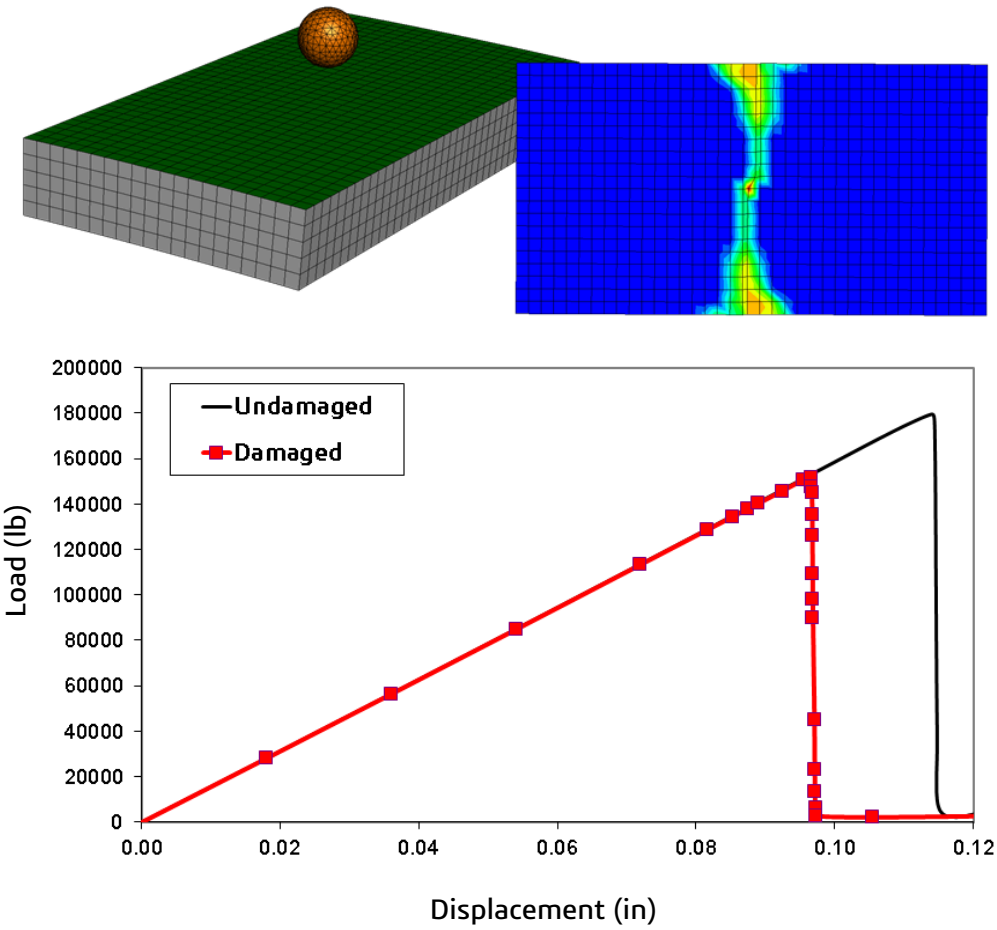
Skin buckling of a stiffened composite panel

Many subsystems, including landing gear, flaps and other control surfaces, are designed to be flexible and to sustain dynamic loads. Engineers can assemble the design data with kinematic and flexible connection definitions in order to create data models with multiple configurations, allowing all aspects of flight to be captured. Implicit and explicit solution procedures are then available to simulate dynamic events such as an aircraft landing and to evaluate the dynamic strength of a subsystem.



Stress distribution in a flap due to aerodynamic loads

The failure modes of materials used in aircraft subsystems are often complex, progressive, non-linear and may occur slowly over many load cycles. The evaluation of appropriate damage initiation criteria enables the engineer to predict the occurrence of such local material failures. However, for certification it is also required to prove that an initial defect does not lead to catastrophic failure throughout the operational life of the structure, i.e. that the structure is damage tolerant. For this purpose, Dassault Systèmes' solution for structural validation provides unique capabilities to simulate crack propagation in metals, progressive damage in composites and debonding of structures, allowing the engineer to determine the residual strength of pre-damaged structures.



Residual strength of a composite sandwich panel with barely visible impact damage

In order to ensure that the appropriate model properties are used in subsystem level simulations, coupon level testing and simulation are often required. Simulation results are calibrated against coupon level experimental data, to determine information such as elastic and plastic material properties, fastener behavior approximations, damage initiation and propagation criteria. With this commonly used building block approach, advanced structural simulation technology is required even for geometrically simple coupon level simulation.

SIMULIA also features fatigue and durability post-analyses at high stress points, calculating life-cycle estimations of components and connections—projected through years of operation, undergoing maneuvers, take-off / landing events, and ground operations.

COMPRESS TIMELINES WITH VIRTUAL STRUCTURAL VALIDATION

Global aerospace industry trends pose several challenges for structural validation of aerospace structures. Accelerated design cycles require compressed timelines to build a database of models for structural validation.

Using the **3D**EXPERIENCE platform reduces non-value added time searching for the right data and developing the right validation model. This compresses the timeline for structural model creation through collaboration and automation from months to weeks.

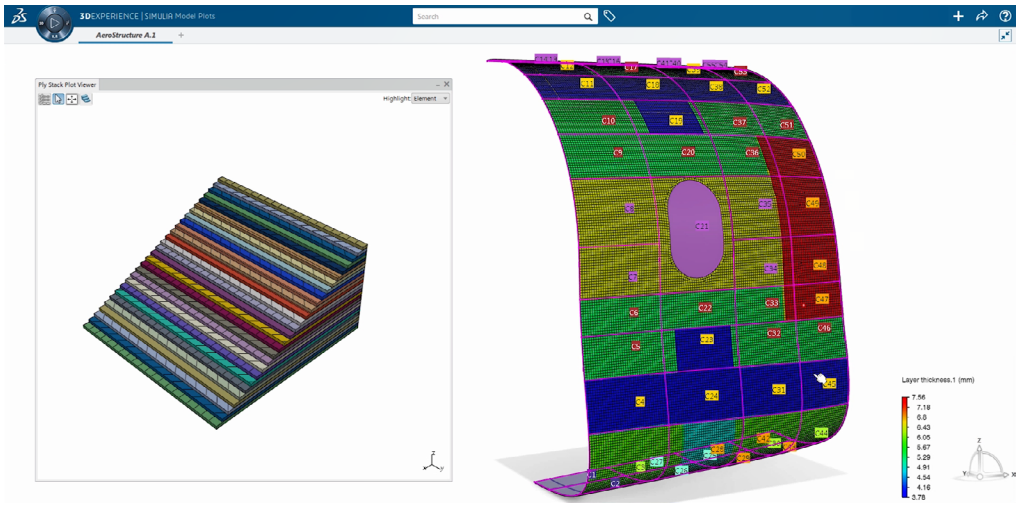
The collaborative nature of **3D**EXPERIENCE enables multiple users or teams to simultaneously work on the creation of structural models for large subsystems. Collaboration is supported by methods to reuse corporate best practices.

Automated modeling technology on the **3D**EXPERIENCE platform makes it possible to automate the creation of structural models for large assemblies, leading to substantial reduction in meshing and modeling time.

LEVERAGE SIMULATION IN EARLY DESIGN PHASES

The earlier critical decisions are made, the fewer costly design iterations are needed later in development. Detailed information about airframe performance is required in early design phases to effectively influence the design. Realistic engineering simulation supports design decisions in all development phases, resulting in reduced weight while maintaining positive margins. Analyzing performance long before the first physical prototype is built reduces the risk of test failures, and not only saves time and money but increases confidence to continue the development.

Fully associated design integration on the **3D**EXPERIENCE platform expedites the creation of structural models in early phases. In addition to the creation of geometry data, the designer usually controls part properties (such as composite layups and material assignments) and fastener data. Full integration with CATIA geometry creation, composite design and fastening apps helps to ensure seamless reuse of this data in structural models.



Reuse of composite layup data in structural models

Since all levels of simulation models are based on and associated with the design model, design updates are easily propagated to all simulation analysts, allowing them to perform selective or automatic mesh and model updates as the design evolves. Likewise, this design associativity supports re-design of the structure based on simulation driven design decisions.

INCREASE CERTIFICATION CONFIDENCE

Increase certification confidence and de-risk programs by usage of accurate and scalable mechanics in all design phases.

Dassault Systèmes' single solver solution for linear and nonlinear structural mechanics covers static and dynamic structural problems as well as thermal-stress simulations. All types of structural nonlinearities can be considered. In particular, a robust general contact capability with geometry-based surface smoothing is available.

A comprehensive library of material models covers linear and nonlinear elasticity, plasticity as well as progressive damage, allowing for realistic modeling of metals, composites and tires. There is also an option to integrate user-defined material models through an open interface.

Unique fracture mechanics capabilities provide the ability to investigate crack propagation in metals and composites using the extended finite element method (XFEM) as well as to simulate the debonding behavior of structures using the Virtual Crack Closure Technique (VCCT) or surface-based cohesive behavior.

The ability to connect Requirements through Test Cases to Simulations ensures traceability from an enterprise perspective. Furthermore, the traceability of simulation objects and simulation results back to the original design data is ensured.

REDUCE EXPENSIVE AND CHALLENGING PHYSICAL TESTS

Using simulation to guide and optimize expensive large-scale tests helps avoid test failure. Securing or even replacing such tests through realistic structural simulation generates a significant business value.

The costs for destructive physical tests up to structural failure are over 10 million USD for large sub-assembly tests and over 100 million USD for full-scale aircraft tests. This puts heavy pressure on engineers to reduce the number of physical tests and perform as much of the analysis as possible digitally.

Complex structural simulations of large-scale models are enabled by best-in-class parallel solver technology. With impressive scaling and robustness, significant reductions in analysis turnaround time can be achieved.

Through efficient data streaming to limit the need for big data transfer and through multi-core parallelization of visualization, very large simulation data sets can be viewed with superior rendering performance and speed. In addition, lightweight simulation results content can be generated for rapid visualization on tablet devices.

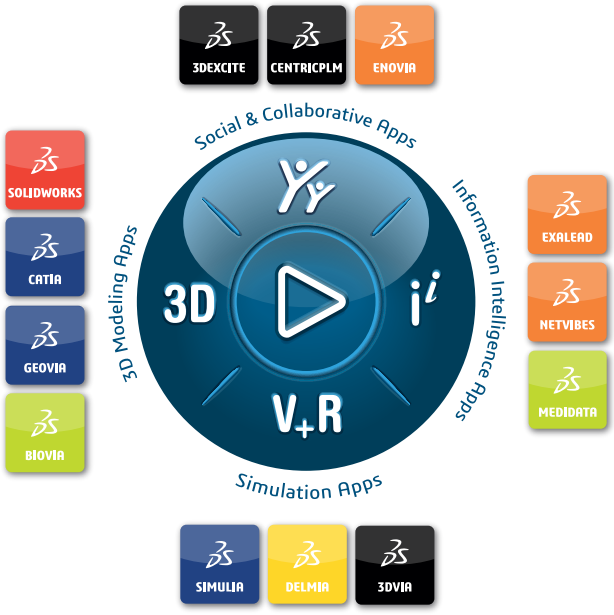
SUMMARY

From coupon level to landing gear systems to complex wing-to-fuselage connections, structural simulations are required to virtually validate certification requirements for static and dynamic strength, damage tolerance and durability. To meet these requirements for innovative designs and lighter weight aircraft, SIMULIA offers advanced simulation capabilities, such as fracture mechanics modeling, a comprehensive material library, and scalable fidelity structural methodologies. Integration of SIMULIA technology on the **3D**EXPERIENCE platform increases engineering efficiency, which compresses timelines, leverages simulation insight early, and increases certification confidence, all of which can ultimately lead to a reduction in costly physical testing.

Our **3D**EXPERIENCE® Platform powers our brand applications, serving 11 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 experience twins' of the real world with our **3D**EXPERIENCE 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 **www.3ds.com**.



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