DASSAULT SYSTEMES | The 3DEXPERIENCE® Company

TAKE OFF WITH REALISTIC SIMULATION

"Aerospace and defense manufacturers need to utilize simulation to gain more insight into product, system, or system of systems performance. Greater insight would help them avoid multiple prototypes and multiple rounds of testing, and that, in turn, would improve their rates of on-time and on-budget delivery." [1]

An integral part of the Dassault Systèmes **3D**EXPERIENCE® Platform, realistic simulation solutions are used by leading aerospace and defense OEMs and their suppliers as part of their integrated development environment to evaluate design alternatives, collaborate on projects, and leverage computing resources for more efficient analysis.

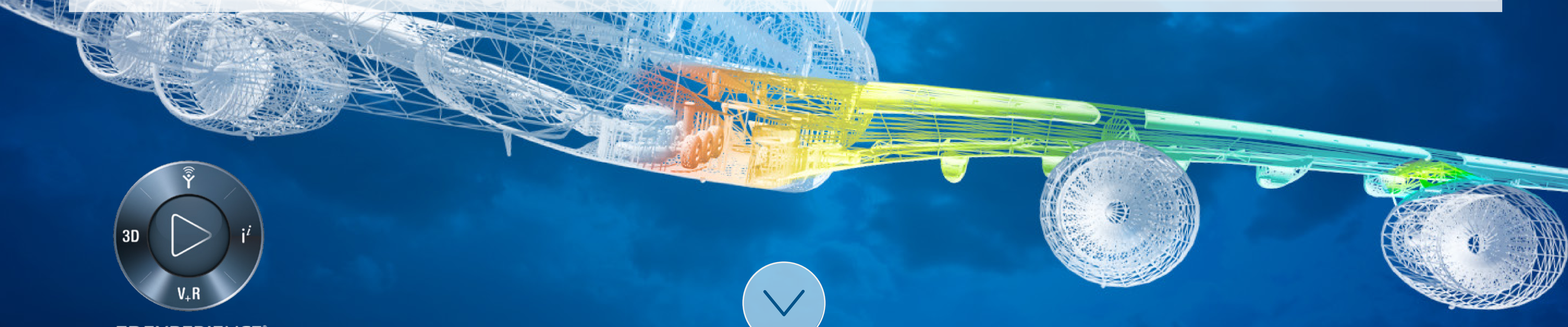
VOLUME 1: MATERIALS

Volume 1 of this eBook series focuses on materials with an emphasis on composites. Read papers from our customers that demonstrate how they use realistic simulation to:

- Reduce structural weight
- Reliably predict mechanical and failure behavior
- Determine residual strength post-impact

Continue reading to view these papers' abstracts—then **download the complete papers!**

[1] Lifecycle Insights: "Improve Program Execution with Integrated Simulation"



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USE OF ABAQUS EXPLICIT FOR COMPOSITE SANDWICH DAMAGE PREDICTION DURING BIRD IMPACT

A method development program of testing and simulations was carried out to develop bird impact NLFEA capabilities of composite sandwich damage prediction and bird dispersion after penetration of the primary layer using Abaqus Explicit. **Curved composite honeycomb panels** (referred to as J-Nose) representing typical composite wing Fixed Leading Edge (FLE) structure were **subjected to bird strike** to generate data for method validation.

The test campaign was tailored to produce various levels of damage and modes of failure; from minor localized core/skin damage to panel perforation. In all tests high speed video were installed to capture the behavior of the structure during the impact. In some tests, fully instrumented witness panel was installed to enable measurement of deformation as a measure of bird residual energy and dispersion after bird penetration of the sandwich panel. **FE models were created of the tested structure and analyzed using Abaqus Explicit** and the results were compared with tests. The analysis performed used a standard Lagrangian bird model developed and validated at Airbus over many years.

In general, good correlation was obtained between tests and simulations results. It is known that Lagrangian bird models suffer from numerical instability in case of impacting sharp edges due to element distortion. To avoid such numerical difficulties, **the SPH capability available in Abaqus/Explicit was used to generate a representative SPH bird model**. Test cases were reanalyzed with the SPH bird model and results compared to the Lagrangian approach. A summary of bird impact simulations and correlation against tests is presented in this paper.

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Courtesy of M. Al-Khalil, E. Kirtil, R. Rigby, Airbus, 2015 SIMULIA Community Conference

RESIDUAL STRENGTH OF THE CARBON FIBER PANEL WITH DELAMINATION

Carbon fiber reinforced materials are getting widely spread. But at present time method of **the calculation of impact residual strength for carbon fiber parts is poorly developed**. Especially this method is underdeveloped in case of the delaminated composite parts. Residual strength is very essential for any project where the composite material parts are used. The possibility to estimate the value of residual strength of the carbon fiber reinforced parts is highlighted in terms of safety for Aerospace structures.

In this work **we propose a method to calculate the carbon fiber panel residual strength of the civil plane wing prototype** with respect to delamination progress simultaneously with degradation law of the material properties. This approach has been developed and realized based on Abaqus software.

All numerical models are presented and the dependence of panel residual strength on the delamination size was shown based on these models.

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Courtesy of M.V. Pavlov, I.A. Zharenov, TsAGI - Central Aerohydrodynamic Institute, 2015 SIMULIA Community Conference

EVALUATION OF ABAQUS XFEM CAPABILITIES FOR CRACK GROWTH ANALYSIS IN AERONAUTICAL STRUCTURES

In the Fracture Mechanics field, standard industrial methods for **crack growth analysis** are mainly based on analytic calculations as classical Finite Element approaches are not practical to deal with discontinuities such as fatigue cracks due to the associated high computational costs. **eXtended Finite Element Method (XFEM)** is one of the methodologies that are being developed in the recent years in order to overcome the limitations associated to classical approaches, especially for complex analysis. However limited industrial experience is available to adopt this methodology as a standard practice in the aircraft industry.

XFEM capabilities available in Abaqus 6.14 have been evaluated by the authors to **assess the reliability and feasibility of the implementation of XFEM methodology to perform crack growth analyses in aeronautical structures**. A set of different cases, common in aeronautical structures, have been selected for this purpose to check Abaqus capabilities on different configurations. In the paper authors presents the results obtained for the evaluated cases and the validation of these results using alternative methodologies for comparison. Current limitations in Abaqus capabilities are also discussed and future developments are proposed for implementation in next Abaqus versions.

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Courtesy of Ismael Rivero Arévalo and Javier Gómez-Escalonilla Martín, Airbus Defense and Space, 2015 SIMULIA Community Conference

PREDICTING IN- AND OUT-OF-PLANE DAMAGE EVOLUTION IN FIBER-REINFORCED COMPOSITES

Fokker Landing Gear has a history in development of **composite technology for landing gear applications**. In order to successfully design and qualify composite landing gear parts it is essential to be able to reliably predict the mechanical and failure behavior of the composite material. Therefore the goal of this study was to **develop, calibrate and validate a material model which can be used to reliably predict the failure behavior of fiber-reinforced composites**.

In the developed material model the **fibers and resin are modelled as separate materials** with their own specific material and failure behavior. The interaction between the fibers and resin is accounted for using a (proprietary) modified Mori-Tanaka approach. For the resin both the plasticity and damage behavior is included. For fiber failure new damage laws have been developed. Cohesive surfaces are used to model the delamination behavior. The **implementation of this material model and cohesive damage laws is done in Abaqus/Standard**. Comparison with test data showed that with the material model the failure behavior in many different tests could be predicted very well.

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Courtesy of W. Wilson, Fokker Landing Gear B.V., 2015 SIMULIA Community Conference

SIMULATING DAMAGE DUE TO A LIGHTNING STRIKE EVENT: EFFECTS OF TEMPERATURE DEPENDENT PROPERTIES ON INTERLAMINAR DAMAGE

A multidirectional, carbon fiber/epoxy, composite panel is subjected to a simulated lightning strike, within a finite element method framework, and the **effect of material properties on the failure (delamination) response is investigated** through a detailed numerical study. The numerical model of the composite panel consists of individual homogenized plies with user-defined, cohesive interface elements between them.

Lightning strikes are simulated as an assumed combination of excessive heat and high pressure loadings. It is observed that the initiation and propagation of **lightning-induced delamination** is a significant function of the temperature dependency of interfacial fracture toughness. This dependency must be defined properly in order to achieve reliable predictions of the present lightning-induced delamination in the composite panel.

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Courtesy of Paria Naghipour, Evan J. Pineda and Steven M. Arnold, NASA Glenn Research Center, 2014 SIMULIA Community Conference

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