COMPOSITE AEROSTRUCTURES

Composite aircraft: enhanced environmental resistance

ONERA

THE FRENCH AEROSPACE LAB

return on innovation

Onera, the key to reducing uncertainty

A composite issue

Composite materials are taking a growing role in aircraft construction, since they are light, corrosion and fatigue-resistant, and easy to shape. However, because of their structure and sensitivity to certain hazards (hail, shock, lightning, etc.), they demand a different approach from traditional metallic materials.

Manufacturers are therefore multiplying the number of tests used, and over-designing parts and assemblies to make sure they can effectively handle the safety risks involved.

This results in higher costs, greater weight and longer development cycles, thus negating some of the competitive advantage of composites.

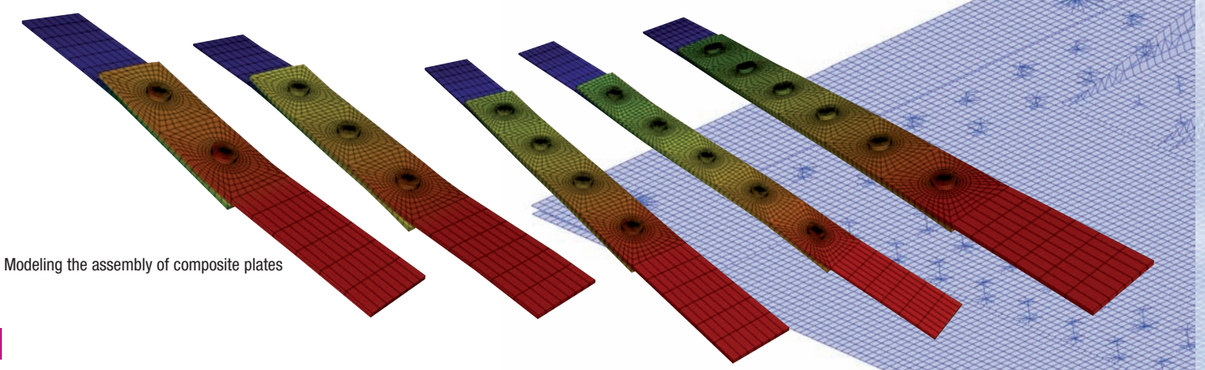
Science and Industry

The answer lies in the development of technologies and models based on a refined understanding of the underlying physics. The researchers at Onera, the French aerospace lab, have been working on these issues for many years, in a unified approach than can be summed up as “think composite”.

Onera gives you access to a wide range of expertise and knowledge:

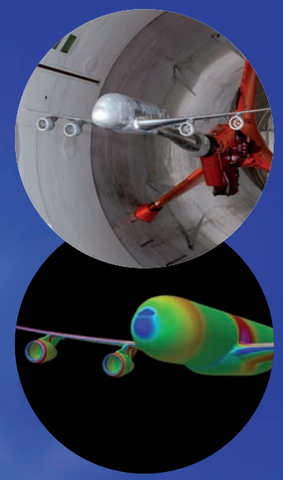
- Fundamental expertise that helps you choose the best technology for a given application as early as possible.
- Development of dedicated models to reduce the number of tests needed.
- Transfer of methodologies for optimum use of test databases.
- Customization of existing Onera models.
- Help in integrating models in your computation process.
- Training and support in using off-the-shelf scientific software.

Our services span Technology Readiness Levels (TRL) 2 to 6 – where the transition from research to industry is most demanding – and are tailored to your investment in composites. Working with your Research & Technology teams, our researchers combine careful attention to your needs, scientific value-added and complete confidentiality to help you build sustainable competitive advantage.



Modeling the assembly of composite plates

Advantages to enhance the value of your composites investment



An A380 model in the wind tunnel, and a numerical simulation

As a gateway between research and applications, with unrivaled capabilities, Onera gives you a decisive competitive edge.

Complementary testing-modeling approach

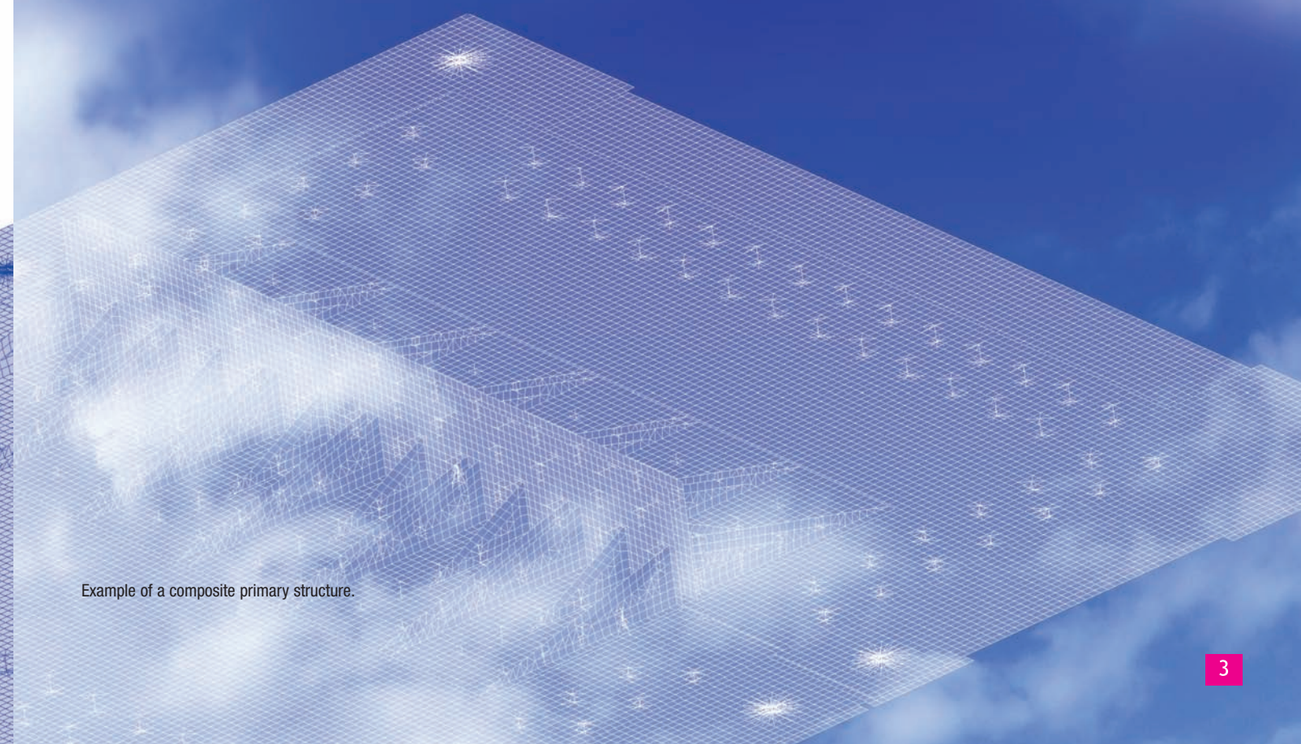
The robustness of the techniques, models and scientific software developed by Onera is based on the ongoing iteration between calculations and physical testing – an area in which we deploy unrivaled experimental resources.

In-depth knowledge of the entire aircraft

Our teams have been involved in aeronautical research for 60 years! You can be sure you’re dealing with seasoned specialists, who know aircraft from nose to tail and how they react with their environment.

Multidisciplinary skills

The multidisciplinary approach is a way of life at Onera, stretching across our 16 scientific departments. For example, the exchange of information based on a comprehensive vision of aircraft has resulted in the coupling of scientific software that was originally created to meet specific problems. This approach is especially applicable to composites, in terms of aerothermodynamics, aeroelasticity, vibroacoustics, fluid/structure coupling and other key issues. It can be enriched by tools such as multidisciplinary design optimization (MDO), employed at Onera for several years already.

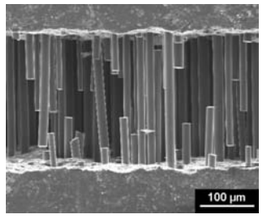


Example of a composite primary structure.

Onera ... when technology risks must be controlled

The management of technology risks is a general goal of all research at Onera, as well as a specific subject of study. The advent of composite materials has spurred research into a number of subjects, generating results that can now be transferred to industry.

Composite materials and structures: enhanced designs, innovative approaches



Composite effect: despite the formation of a crack, the fibers joining the two parts maintain good cohesion

Requirement

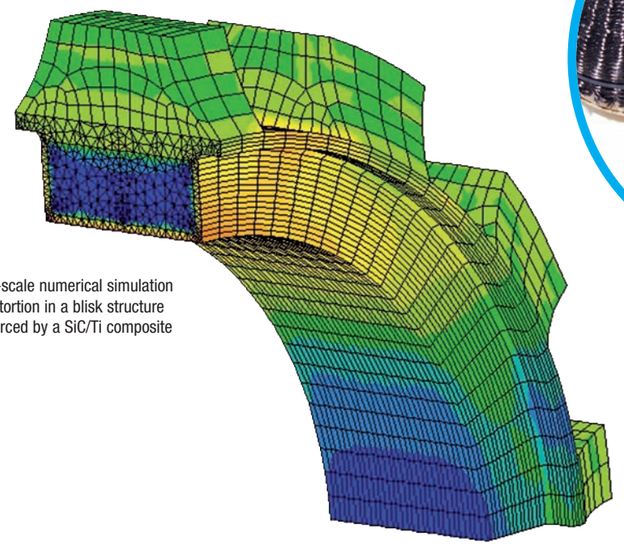
Ensure safety margins by integrating reliable uncertainty factors throughout the scalable test process, from the original material sample to the complete structure, taking into account the highly specific damage characteristics of composite materials.

Onera's solution

Offer scientific software and models covering:

- Production, to optimize the process in terms of expected results.
- Structural integrity, on typical industrial cases.
- Variability management.

Detail of a woven-fiber shaft root



Multi-scale numerical simulation of distortion in a blisk structure reinforced by a SiC/Ti composite

Modeling structural behavior during crashes

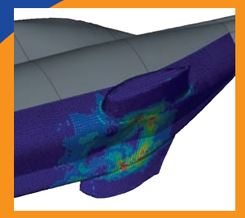
Requirement

Demonstrate that a structure meets certification requirements, taking into account the major differences between composite and metallic materials (lack of plasticity, for example), in case of a very-high-energy dynamic impact.

Onera's solution

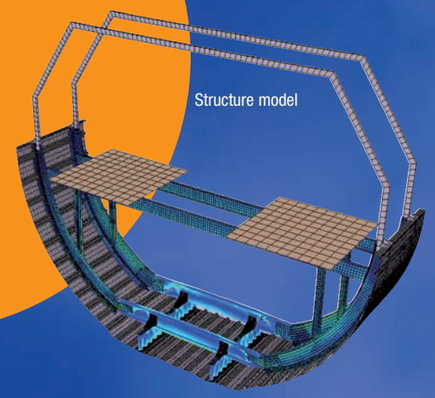
Faster, less expensive development, based on a full slate of services:

- Expert advice to choose the best technology.
- Methodology transfer to industry, enabling manufacturers to develop their own models.
- Aid in using off-the-shelf software.



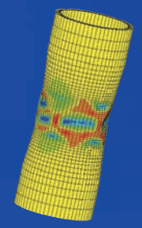
Visualization of external distortions experienced by a helicopter structure during a crash at sea (Puma helicopter)

Structure before crash test



Structure model

In particular, Onera draws on 15 years of collaboration with Eurocopter in modeling the crash behavior of the Tiger helicopter (all-composite airframe).



Numerical simulation of the buckling of a composite tubular structure

Controlling heat transfer within composite structures

Requirement

The organic matrix composites used in aircraft structures are thermally insulating materials, which means that they stock heat instead of transferring it. This could create "hot points", degrading the mechanical properties of the material and even creating a fire risk.

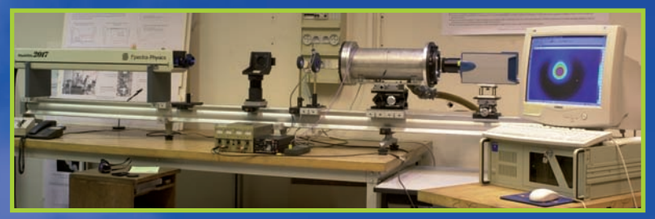
Onera's solution

We have developed several methods to:

- model heat transfers;
- predict the impact of a fire.

Continually improved, our methods were already used to create specific models for the A380 super-jumbo jet.

Thermo-physical characterization test stand for composite materials



Non-aggressive deicing of composite structures

Requirement

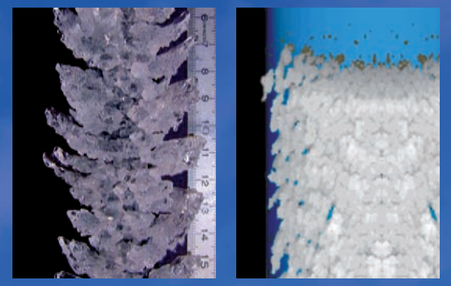
A pulsed hot air deicing system behind the wing leading edge cannot be used with organic matrix composites because this material's mechanical properties degrade above 180°C.

Onera's solution

- Study new systems designed for use with composites.
- Develop the software simulating their operation.

Onera is the sole supplier of icing models in Europe.

Test and simulation of "lobster-tail" icing



Controlling the external impact of lightning

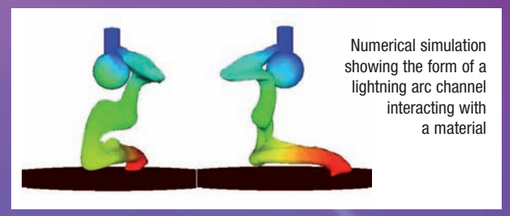
Requirement

Characterize the lightning resistance of composites, in which the electric arc moves in non-linear fashion, unlike metals, leading to a risk of structural degradation.

Onera's solution

- Experimentally characterize composites, based on current research and previous work on metallic materials.
- Develop predictive tools.

Damage resulting from a lightning arc on an aluminum plate



Numerical simulation showing the form of a lightning arc channel interacting with a material

Controlling the internal impact of lightning

Requirement

Given that composite aircraft do not offer a grounding effect at low frequencies, we need to know the distribution of currents along the skin of the plane, and the resultant impact on electronics.

Onera's solution

- Analyze the surface impedance of carbon materials and junction zones in the structure.
- Develop digital tools to qualify wiring assemblies.

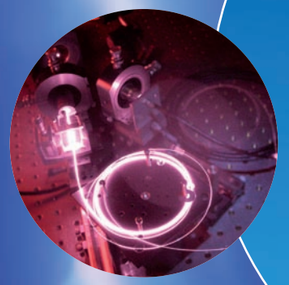
Managing turbulence in clear skies

Requirement

Identify ahead of time air holes, bursts, shear and other turbulence occurrences in clear skies, and adapt the flight controls to the characteristics of the composite aircraft, which is more rigid and therefore more sensitive to these events.

Onera's solution

- Design an airborne instrument, such as a Lidar, capable of detecting air movements ahead of the plane.
- Design actuators and adapt flight control design methods to integrate these phenomena within the composite aircraft environment.



Fiber laser source

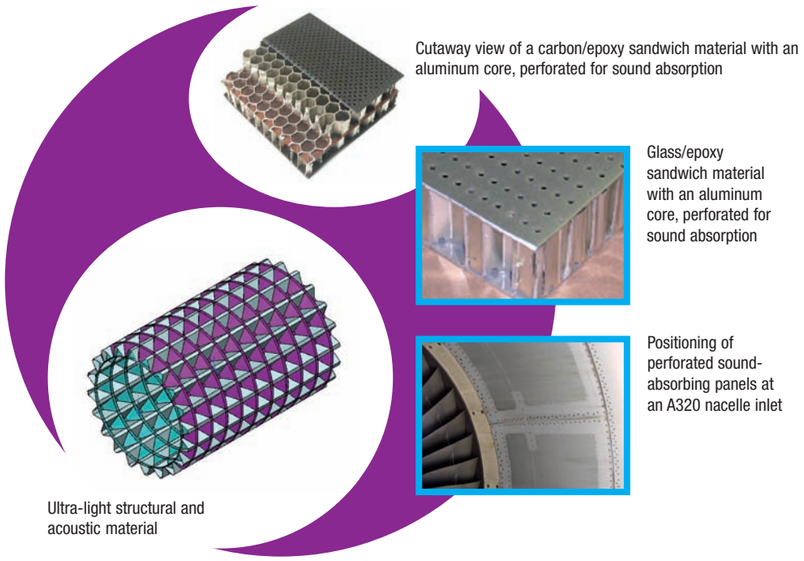
Forecasting internal noise

Requirement

Predict the vibroacoustic behavior of a composite aircraft, to improve passenger comfort without having to add acoustic insulation that would increase weight.

Onera's solution

Propose reliable methods and software to predict internal noise in composite structures, validated by testing and applicable to a complete aircraft.



Cutaway view of a carbon/epoxy sandwich material with an aluminum core, perforated for sound absorption

Glass/epoxy sandwich material with an aluminum core, perforated for sound absorption

Positioning of perforated sound-absorbing panels at an A320 nacelle inlet

Ultra-light structural and acoustic material

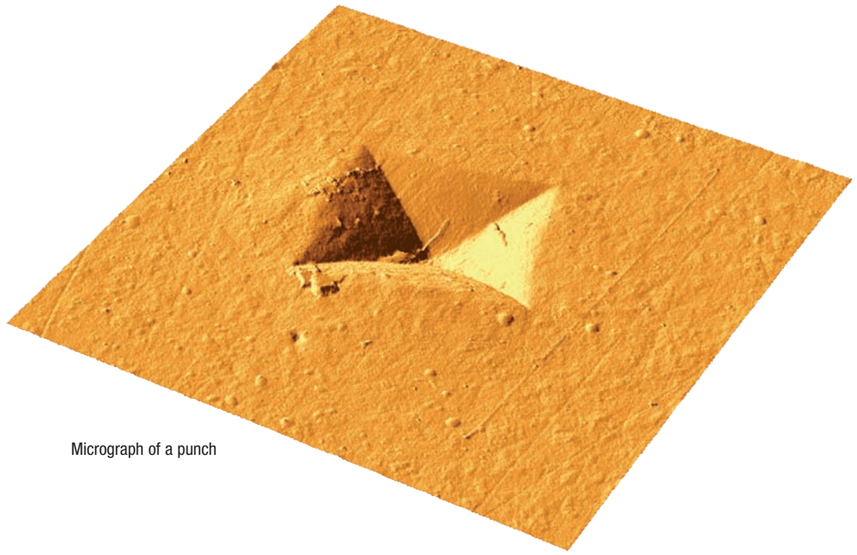
Composite structural health monitoring (SHM)

Requirement

Enable aircraft operators to know whether a composite structure has experienced any damage, without having to ground or disassemble the aircraft. Analyze loss of capability, predict changes over time, choose the best repair technique and test performance restoration. The end goal is to reduce maintenance costs.

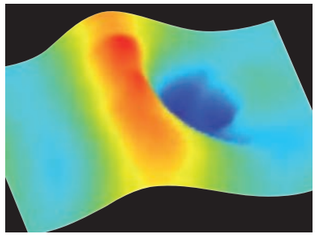
Onera's solution

- Provide support in choosing and testing onboard non-destructive testing methods (SHM).
- Model the physics of damage mechanisms and propagation.



Micrograph of a punch

Visualization of the intensity of Lamb waves



Simpler, faster repair methods

Requirement

Limit the time aircraft are grounded to reduce maintenance costs, by calling on an array of repair techniques suited to different types of materials and structures, as well as locating damage.

Onera's solution

Develop and propose new techniques (resin infiltration for instance) that make the repair process simpler and faster, and capable of correcting manufacturing incidents or impact damage.

Onera, the leading aerospace research organization in France

Onera carries out application-oriented multidisciplinary research for both industry and government. It has more than 2,000 employees and annual business volume of 189 million euros.

Organized in 16 scientific departments and deploying world-class test facilities, Onera's staff span the full range of disciplines needed by the aerospace industry: energetics, aerodynamics, materials & structures, flow physics, electromagnetism, optics, atmospheric and space environment physics, information processing and complex systems, long-term design and system integration.

Onera is the bridge between basic research and technology applications.

Contact:

Jacques Gatard
Business Development and Commercialization
Civil Aircraft and Air Transport Systems
Jacques.Gatard@onera.fr
Tel: +33 6 15 30 02 39

Cover: SpaceShipOne under its carrier aircraft, White Knight 1, built by American company Scaled Composites. The structure is mainly of a carbon fiber-reinforced composite material.

www.onera.fr

ONERA

THE FRENCH AEROSPACE LAB

return on innovation

Published by Onera - Communications Department • December 2008 • Photos: Onera, © 2004 Mojave Aerospace Ventures, LLC, Photo by Scaled Composites, SpaceShipOne is a Paul G. Allen Project.