



# Aerospace science at your fingertips

ONERA

THE FRENCH AEROSPACE LAB

r e t u r n   o n   i n n o v a t i o n

**A**t Onera, we develop the technologies that will underpin the success of your new programs. Onera is 2,300 people strong (including doctoral candidates), with expertise spanning all key aerospace and defense disciplines: optics, electromagnetism, sensors, physics, fluid mechanics, energetics, information and image processing, systems, materials, structures and more.

Contact us! We may already have the solution you need to get your project off the ground.

## Creating value through science, delivering turnkey solutions

Onera delivers exclusive competitive advantages with high added-value, based on our outstanding aerospace science and technology capabilities.

### Research and design

Do you need to expand your knowledge base to bring a project to fruition? We help specify your exact requirements, nurturing your project through our broad knowledge of physics and advanced applications. We set up a dedicated research team for your project, delivering scientific excellence with guaranteed quality, confidentiality and on-time delivery. Onera has the full array of skills and resources needed at every stage in the innovation value chain: from understanding the underlying physics to building technology demonstrators, not to mention modeling, simulation, experimentation and testing.

### Top-flight testing

Onera has earned a global reputation for our wind tunnels. But we also deploy over 150 world-class test benches in energetics, electromagnetism, acoustics, optics, vibrations, materials and other disciplines. Our scientists can handle all of your testing needs, with service packages including test design and analysis of results.

### Powerful numerical simulation software

Aerodynamics, energetics, structures, materials, EMC, radiation... Onera has developed powerful numerical simulation tools in all of these core disciplines, proven through extensive experimentation and ready for immediate use by industry, under license.

### Technology transfer

Onera regularly develops innovative new techniques and solutions, which are then patented. These technologies are available for licensing, along with scientific support to apply these solutions at the industrial level.

### Industry support

Onera is a team of world-class scientists and engineers spanning 40 cutting-edge disciplines. We provide proven guidance and also give you concrete solutions to meet your specific requirements.

### Long-term planning

Onera is an advanced research engine. Top experts from different scientific disciplines form integrated project teams to provide recommendations on how to meet your challenges. We have developed a broad range of applications and methods to evaluate new concepts.

### R&D directions

Our researchers can help you make the basic technology decisions for your next-generation programs – those that will enter the development pipeline in five or ten years, and stay in operation, evolving continuously, for another 30 to 40 years.

Onera has established a broad network of contacts thanks to partnerships with leading aerospace research organizations in over 30 countries. Because of our international experience, Onera can support your own business in many areas:

- > providing the technological differentiators for your proposals;
- > meeting specific R&D needs in international partnerships;
- > developments in export markets;
- > setting up specific training programs;
- > supporting your strategy in offset agreements.

These actions can be part of your corporate strategy for winning new contracts, or expanding operations into new markets.



## The multidisciplinary advantage

By teaming up with Onera, you access a network of scientists and engineers with highly complementary skills to help you resolve even the most complex problems.

### Aerodynamics

- > Experimentation, numerical simulation, metrology
- > Physics of underlying phenomena
- > Optimization and new concepts
- > Aerodynamics of aircraft and associated systems

### Energetics

- > Propulsion systems
- > Experimentation, numerical simulation, metrology
- > New propulsion concepts
- > Reactive flow physics
- > Fuels and energetic materials

### Materials

- > Microstructure studies
- > Intelligent systems and structures
- > Characterization methods
- > Structural design and resistance
- > Metallic, refractory, composite materials
- > Structural dynamics and vibration, aeroelasticity
- > Damage mechanisms and behavioral analysis

### Information processing and systems

- > Control and decision-making
- > Data processing
- > Flight mechanics, flight control, guidance, navigation
- > Onboard intelligence
- > Complex systems
- > System concepts

### Physics

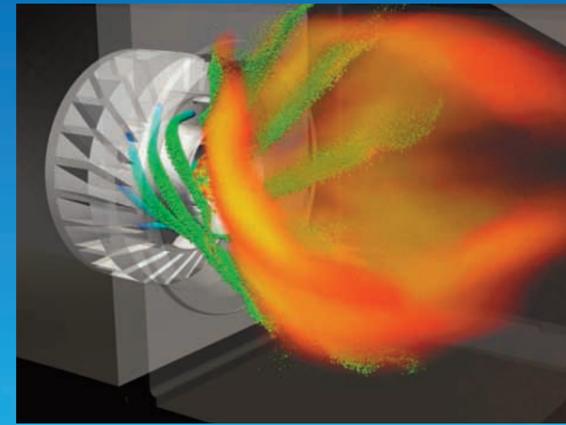
- > Air & space environments
- > Optics, optronics, photonics
- > Electromagnetism and radar
- > High-performance sensors

### Innovative solutions

- > Plasma
- > Cold atoms
- > Nanomaterials
- > Microtechnologies
- > Functional materials

Research by Onera is transformed into innovative solutions to meet the challenges facing both industry and society as a whole.

For example... >>>



### Reducing polluting emissions

Onera develops its own computation codes, powerful software programs that let us simulate complex aerodynamic phenomena, leading to hypotheses which can then be validated on test rigs. With European authorities setting increasingly draconian environmental standards, Onera offers a service that makes a difference: version 4.1 of our Cedre computation code, which allows our partners to carry out complete computations of what occurs in combustion chambers, and evaluate the production of different polluting compounds, such as soot, oxides of nitrogen, or carbon monoxide. Once these emissions have been characterized, engine manufacturers can design their combustors to consume less fuel and decrease emissions.



### Aircraft vibration tests

Onera deploys a unique instrumentation method to test the vibration behavior of structures on the ground and in flight. It has drawn the attention of customers across the sector, including manufacturers of aircraft (Airbus, Dassault), engines (Snecma) and missiles (MBDA), as well as French space agency CNES. Onera deploys this method to characterize the dynamic behavior of mainline commercial jets, based on the installation of hundreds of sensors and our ability to process large quantities of data. We have conducted vibration tests on all models in the Airbus family, from the original A300 widebody twin to the A380 super-jumbo. We are also participating in the vast European research program Clean Sky, including studies on how to reduce the stress experienced by aircraft when they fly through turbulence.



### Reducing noise

Onera is actively working on breakthroughs to continue the advances achieved over the last 40 years and meet the objectives set by European authorities, such as cutting perceived noise in half by 2020 (vs. 2000). Onera launched the Iroqua noise reduction initiative in 2005, uniting partners from industry and academia.

Our research concerns both the aerodynamic noise generated by the airframe and the engines. It draws on advanced experimental facilities, such as the Cepra 19 anechoic wind tunnel, specially designed to measure the jet noise due to the ejection of hot gases from a nozzle, as well

as the Iesta platform, an application designed to simulate and evaluate the overall noise impact of different air transport systems. Special test facilities are also being installed to study the noise generated by open-rotor type engines, in the large wind tunnels at Modane.

Looking further ahead, Onera is addressing the problem of noise around airports, which has become an issue for society in general. For instance, we are working with experts in human sciences and psycho-acoustics to better understand the perception of aircraft noise.

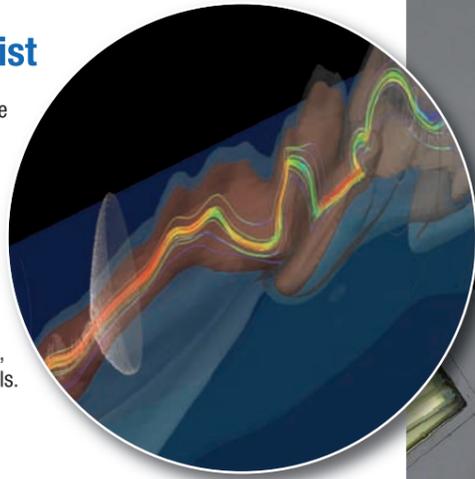
## Lightning specialist

Onera is capable of digitally simulating lightning to calculate the complete path of an aircraft lightning strike. We have been conducting research in this area since 1978, to help manufacturers develop new lightning protection technologies.

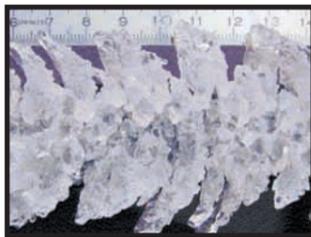
Our research has enabled us to calculate the path of the lightning strike on the structure, and the associated current paths in the internal wiring.

To continue our progress in this critical field, Onera set up a special "lightning lab" in mid-2011. Our aim is to better understand and analyze structural damage mechanisms related to lightning.

And these studies will be all the more useful on new-generation aircraft, given the constantly growing use of composite materials.



## Teaming up with NASA to control icing



Since 1980, Onera has deployed its experimental and numerical simulation systems to better understand and control icing on aircraft wings. For example, the Eclips program, carried out with Eurocopter, Dassault and Airbus, was able to characterize the degradation in performance of an iced-over wing, by using Onera's elsA computation code. We can also validate these simulated phenomena by using full-scale tests in our large wind tunnels. One of the leading-edge experimental measurement techniques used is PIV, or Particle Image Velocimetry, which visualizes flows around the ice. Because of these powerful testing methods, Onera has been chosen as a partner by prestigious organizations such as NASA, which has teamed up with Onera since 2005. The latest Sunset 2 project should extend this collaboration between Onera, NASA and the FAA from 2012 to 2017.



## Integrating drones in air traffic

Onera is a pioneer in research on unmanned aerial vehicles or systems (UAV/UAS), also known as drones. Drones drive innovation and encourage technological breakthroughs. At Onera, we call on our full range of skills to support research on drones, including aerodynamics, energetics, materials, sensors, information processing, command-control, optics, electromagnetism, certification, etc.

The two main challenges are to provide drones with operational autonomy and automate the air traffic system. Onera acts as an independent expert for projects such as Midcas (mid-air collision avoidance system), designed to allow drones to perform like manned aircraft. We are also taking part in the European project Oparus, which aims to define a surveillance architecture for drones, and we are behind the "Ideas" project, to develop the technological and methodological resources needed to safely integrate drones in air traffic.

Onera is also a driving force behind more general air transport system projects, considering, for example, the automation and integration of all types of aircraft in air traffic. The PPlane project aims to develop an automated personal plane, while 4DCo-GC is designed to automate aircraft guidance in 4 dimensions – an impossible task for human pilots because of the degree of precision required.

## A fleet of wind tunnels to assess breakthrough technologies

### Decision-making aid for industry

Onera's fleet of advanced wind tunnels is a key to managing risk and evaluating performance during the aerospace design phase. Our wind tunnels are routinely used by industry leaders such as Airbus, Eurocopter, Dassault, MBDA and Safran to provide the aerodynamic data that will determine shape, performance, handling qualities, safety margins and noise levels. Manufacturers rely on these measurements to make critical decisions, and reduce uncertainty prior to the first flight.

### Different wind tunnels for different needs

Onera's 12 major wind tunnels account for more than half of the total in Europe. They are located at Onera research centers across France, in Modane-Avrieux (Savoy region), Fauga-Mauzac (south-west), and the science cluster in Saclay, near Paris. Our broad range of wind tunnels, unrivaled worldwide, covers the speed range from Mach 0.1 to Mach 20, or low subsonic to hypersonic!

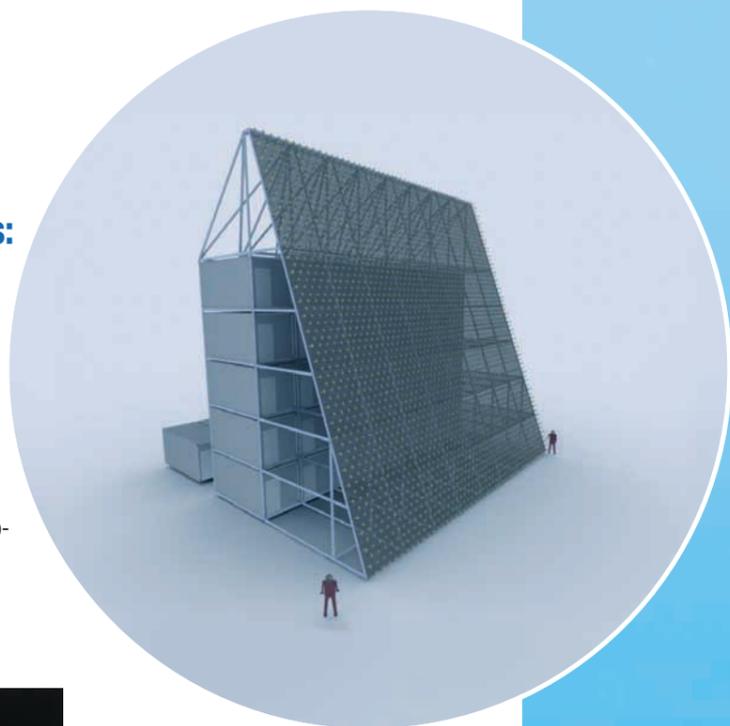
### Boosting competitiveness and environmental-friendliness

Fully two-thirds of Onera's wind tunnel business is designed to decrease the environmental footprint of commercial airplanes. The main breakthrough technology now under consideration for civil aviation is the open rotor layout, since it could significantly reduce fuel consumption and therefore CO<sub>2</sub> emissions. More than 30 million euros have been invested at Modane to develop facilities that will generate the aerodynamic and acoustic data needed to evaluate open-rotor type engines. The S1MA wind tunnel at Modane and the F1 facility in Fauga-Mauzac, the only tandem of its kind in the world, are used to explore the entire flight envelope on large-scale models. Other equally revolutionary concepts are tested and developed on these facilities, including natural laminar flow, as well as unsteady flow control on wings.



## Radars and optronic imaging: airborne Earth observation

A veritable flying lab, Sethi is a radar and optronic imaging system mounted on an aircraft, allowing scientists to gather the wide variety of data needed for their research. Through its advanced radar and optronic sensors, Sethi generates high-resolution images, detects activity indices (thermal analysis) and provides a fine spectral analysis of scenes, from the visible to far infrared bands. Sethi offers a number of different measurement configurations, making it an ideal testbed for scientific, environmental or security applications.



## Ballistic missile warning systems: Onera's long-standing expertise

Onera has conducted research for more than 30 years on ballistic missile warning systems, in conjunction with Thales and on behalf of the French defense procurement agency DGA, leading to the definition of a very-high-performance radar warning system. The radar concept developed by Onera is capable of detecting even very small objects at longer range, under a wide variety of flight configurations. The DGA congratulated Onera for its development of this new radar concept.



## Scorpio, the innovative infrared detector

After seven years of basic research in optics, Onera has succeeded in integrating an optical lens in an infrared detector, a model produced by the company Sofradir. This successful technology transfer resulted in the production of a demonstrator capable of independently producing an image without requiring additional optical components – a feat of technological prowess that reduces the number of optical and electronic components used in infrared imaging systems by about one-third, to significantly reduce their size and cost. The Scorpio detector by Sofradir offers a very wide field-of-view, perfect for both surveillance and security applications.



## The only space surveillance system of its kind in Europe

Graves is the only independent space tracking and surveillance system now in operation in Europe. Designed from nose to tail by Onera, and operated by the French air force, it automatically maintains a complete database covering some 2,500 satellites. Graves not only detects these orbital objects, but also tracks them and calculates their trajectories, based on measurements by its integrated radar. The French air force is fully satisfied with this system, in operation since 2005, and in 2010 asked Onera for an upgrade. Improvements will mainly involve an extended catalog of trajectories (including smaller and/or higher altitude satellites), plus greater accuracy and system availability, thanks to new built-in test equipment. The improved version will also include a new spatial analysis service, which will evaluate space collision risks.

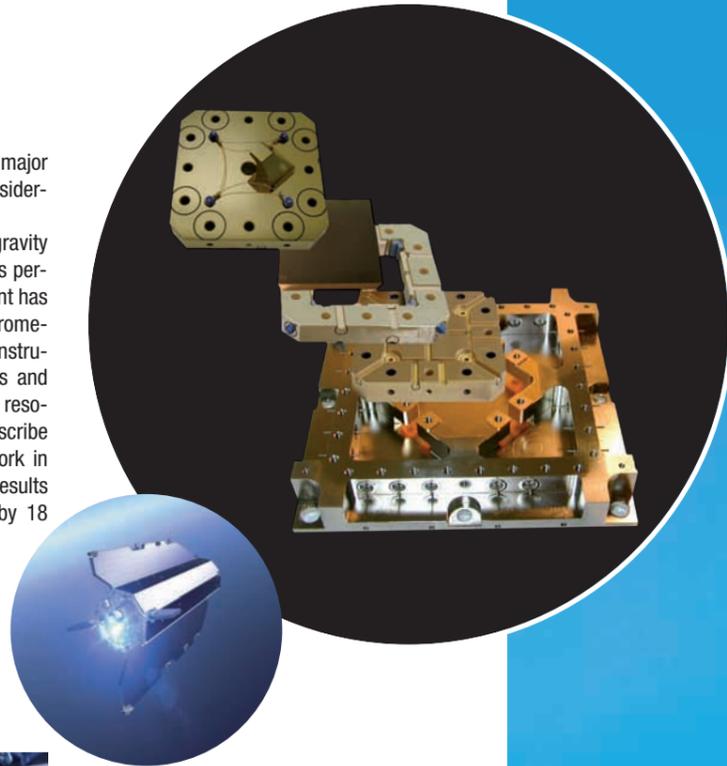
## Surface wave radars to see over the horizon

The result of 20 years of research on low-frequency radars, originally designed for defense, our surface wave radar (SWR) uses the sea surface as a propagation channel to provide exceptional maritime surveillance capabilities. It can detect ships at up to 400 kilometers from the coastline, as opposed to conventional radars, whose range is limited to 50 to 100 kilometers. This allows coastal countries to monitor their Exclusive Economic Zone, recently extended to 200 nautical miles. The SWR complements current coastal surveillance systems. A first-generation SWR has been transferred to Thales, while a second-generation model is under development by Onera on behalf of the French Ministry of Defense. This new demonstrator, based in the Mediterranean, will be dedicated to the detection of small craft.



## Earth Observation: mission accomplished thanks to Onera accelerometers

Since 2000, accelerometers by Onera have flown on three major space missions – Champ, Grace (NASA) and Goce (ESA) – considerably advancing our understanding of the Earth's gravity field. After two years in orbit, and 12 months of actively gathering gravity field data, Goce is a remarkable scientific success. It owes this performance to a tri-axial gradiometer, the first time this instrument has been used in space, and six ultrasensitive electrostatic accelerometers, designed and developed by Onera. These high-precision instruments provide critical data to oceanographers, seismologists and geophysicists, helping measure the geoid with unprecedented resolution. This enables them, for example, to more accurately describe ocean circulation and better understand the processes at work in movements of the Earth's crust. Because of the high-quality results and the satellite's good health, ESA extended the mission by 18 months, to December 2012.



## Eole, an innovative airborne launch system

Is there a way to launch micro and mini-satellites that would be both quicker and more cost-effective than conventional rockets? And how can we characterize their release dynamics? For the last few years, Onera has teamed up with French space agency CNES on a reduced-scale flying demonstrator called Eole, a new launch system in which a reusable automated vehicle replaces a conventional first stage. Through the Eole project, Onera brings together academia (research program open to students at the ISAE and Arts & Métiers PariTech engineering schools) and industry (Aviation Design). The vehicle is being built by Aviation Design, which calls on Onera's scientific expertise and test facilities. Eole will fly for the first time in 2012, and should be operational a year later.



## Porous titanium prostheses

Who could have imagined that an advanced technology developed for catalytic converters would one day find an application in the medical sector? But that's exactly what happened with one of Onera's emblematic technology transfers. Thanks to timely support from Onera, a small company called Protip is now offering biocompatible prostheses, capable of replacing certain human organs, such as the larynx. Onera originally developed an innovative production process for catalytic converters: a stack of tiny balls, bonded together. It turns out that this technology produces a strong yet porous material which can be easily colonized by living cells. Our collaboration is continuing, with the production of a valve made of nitinol (nickel-titanium), that could eventually be integrated in esophageal implants.

## Atmospheric measurements via laser



After Onera's successful technology transfer to Leosphere, resulting in the "Windcube" (wind speed measurement for wind turbines), this company is now marketing a new long-range wind profiling lidar, using a fiber laser source developed by Onera. In the wind-field mapping version of this device, the signal processing algorithm also resulted from teamwork between Onera and Leosphere. This product could be used, for example, to monitor dangerous wind phenomena around airports.



## More efficient wind turbines

The technologies and expertise that Onera has developed for aerospace can also be applied to wind turbines, including composite materials, structures, aerodynamics, lightning and icing control, acoustics and radars. Teaming up with the wind turbine industry for many years, Onera will take a full-fledged role as this industry really comes into its own. In 2007, for instance, Onera helped Nheolis develop a new-generation wind turbine based on 3D aero design, one that was lower, quieter, more efficient, and capable of operating across a broader range of wind speeds.

Another concern is that wind turbines sometimes disturb the operation of radars, especially weather radars. Onera is participating in a research program launched by the French Ministry of Ecology and Energy, and coordinated by Ademe, the French environmental and energy management agency: we help model and understand these disturbances, then simulate future wind turbine installations. We are also participating in another facet of this program, namely making wind turbine blades "stealthy" by using radar-absorbent materials integrated in the blades, via a demonstrator built by EADS Astrium.



Onera is the leading aerospace and defense research organization in France, accounting for 25% of all Research & Technology (R&T) in this strategic sector. Founded in 1946, Onera is a public research establishment reporting to the Ministry of Defense. It counts over 2,000 employees, plus some 220 doctoral candidates and post-docs at eight main facilities in France. Onera is the only organization in France with expertise spanning all aerospace disciplines, and deploys a fleet of experimental facilities that is unrivaled in Europe. Onera works for agencies, governments and industry, from large corporates to innovative small businesses. Offering an atypical model of partner-based research, and having earned two Carnot research institute labels, Onera carries out five times as much contract research per researcher as the national average. A driving force in innovation, expertise and long-term planning, Onera has contributed to many of today's leading aerospace and defense programs, including the Ariane 5 launcher, the Airbus commercial jet and Eurocopter helicopter families, the Rafale fighter, the Falcon business jet, the Graves space surveillance radar, the Very Large Telescope and much more.

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[www.onera.fr](http://www.onera.fr)

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