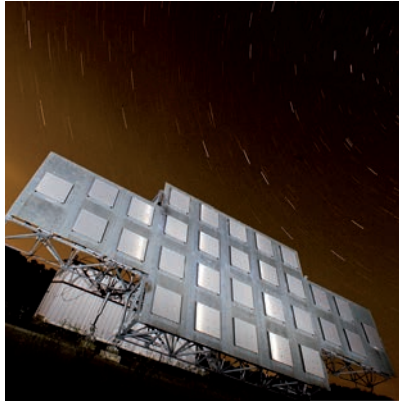


ANNUAL REPORT

2024



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ONERA, a key player in aeronautics and space research, employs more than 2,200 people. Under the supervision of the Ministry of the Armed Forces, it has a budget of €336 million (2024), more than half of which comes from study contracts, research grants and the development of new technologies, research and testing. As a government expert, ONERA is preparing tomorrow's defense, meeting the aeronautics and space challenges of the future, and contributing to the competitiveness of the aerospace industry. It masters all the disciplines and technologies in the field. All the major civil and military aerospace programmes in France and Europe include a part of ONERA's DNA: Ariane, Airbus, Falcon, Rafale, missiles, helicopters, engines, radars, etc. Recognised internationally and often awarded prizes, its researchers supervise many doctoral students.



BRUNO SAINJON,
CEO OF ONERA

A substantial part of national sovereignty in the fields of defence, in particular nuclear deterrence, aeronautics and space, relies on ONERA.

This mission has been in its DNA since its creation in 1946. As we'll celebrate the 80th anniversary of its creation next year, ONERA is more than ever looking to the future. To achieve this, ONERA relies upon the trust of its partners, first its supervisory body, the Ministry of the Armed Forces. Conversely, the State knows that it can rely on ONERA.

While the geopolitical instability is heightening the threats towards France and the European Union, ONERA scientists are ready to meet all the challenges related to

the nation's sovereignty in its field of expertise. This annual report aims to show the reader how the results achieved by ONERA justify the trust granted by its partners.

The order intake record for 2024 (€195m) is a relevant sign of this trust the Office enjoys, whereas the 2023 record already seemed out of reach. As last year, the DGA accounted for the predominant part of this order intake (€56.7m), in particular via a major contract related to deterrence.

Edito

I see in this progression over the last few years a growing need for "ONERA inside" science expressed by our partners and customers, whether state or industrial, national or foreign. I also see it as the fruit of considerable work achieved by the Technical and Programmes Division and the Wind Tunnels Division to build up a first-rate scientific offer, hence to deliver outstanding results. Working hand in hand with their ONERA colleagues in the Scientific and Foresight Division and those in charge of research support, our scientists are rightly proud of these successes. This annual report shows just some of them.

Contractual activity also reached a record level of €206m, so that the share of our budget accounted for by the public service charge subsidy (38%) is now lower than that of our own income.

In this respect, the increase in contractual production (+50% in five years), which is much faster than the increase in the workforce (+6% in five years), demonstrates the extraordinary commitment of employees to cope with this strong and continuous increase in orders. It also highlights the risk of undermining long-term projects if our workforce ceiling is not quickly redefined; moreover it already has very short-term consequences for several activities for which we can no longer cope with the numerous demands, particularly in the wind tunnel sector.

But the long-term challenges are definitively there. The update of the Strategic Scientific Plan, to be published in 2025, shows just how much ONERA's work on the scientific challenges of the Defence-Aeronautics-Space sector is expected, as expected from our roadmaps in 2023. Combined with a good control of expenditures, this high level of contractual activity has led ONERA to achieve a positive net accounting result for the tenth consecutive year, rising €9.1m in 2024. All the ONERA's employees have contributed to this result, and they deserve to be congratulated.

This strong mobilisation is occurring as the first major projects of the PRISME programme have begun in the Palaiseau centre, with buildings that will house the General Secretariat's services, the medical-social services, the training activities and the computing centre, among others. The year 2024 also saw the extension of the wind tunnel mockups workshop in Lille, which was inaugurated on 1st October in the presence of Mr. Xavier Bertrand, President of the Hauts-de-France region.

As illustration of the increase in order intake, the partnership signed with SAFRAN on 19 January 2024 provides a 4-year framework for future wind tunnel tests, particularly around the development of the future "ECOENGINE" open fan engine. Signed in Modane, it provided the opportunity of a press trip highlighting the high technical expertise of

ONERA's teams, operating on facilities of outstanding quality.

While many people are talking about quantum technology and artificial intelligence, ONERA delivered two operational devices in 2024. The GIRAFE quantum gravimeter, delivered to the French Navy, made it the first army in the world to be operationally equipped with second-generation quantum technology. And the SINAPS software, equipped with AI to assist air traffic controllers in decision-making, was deployed across the 5 air traffic control sites that cover the mainland France.

The promotion of our skills continued with the first training sessions on the MATISSE software as part of ONERA Academy®. In 2024, the Qualiopi certification process was also launched to guarantee the quality of our professional training courses and allow our partners to benefit from funding for the training of their employees. This certification was obtained in January 2025.

In the 2023 annual report, I announced the creation of our first space surveillance services subsidiary, ASTAREON. In 2024, the capital increase subscribed by HEMERIA paved the way for the development of this activity. The new company, now 70% owned by HEMERIA and 30% by ONERA, has taken the name HEMERIA - Surveillance.

In a context of fierce competition and international tensions, ONERA continues to attract talent: 233 new employees joined ONERA in 2024, and the new recruitment website launched this year reflects the ONERA's values to strengthen our attractiveness. We have many scientific and technical challenges to offer them! They are joining a community committed to preparing the future of Defence, Aeronautics and Space, while at the same time considering the current societal issues. We are also tackling these challenges thanks to collaboration with our academic partners. The collective reflection undertaken following the joint request made to ONERA by the DGRI, DGA and DGAC to define a national roadmap for upstream scientific research for civil aeronautics perfectly illustrates ONERA's positioning on the continuum from fundamental research to industrial developments.

On the international level, one of the many highlights was the 15th IFAR summit, under the ONERA presidency, which allowed our teams to showcase the world-class level of their work and to exchange ideas with their colleagues from all over the world. I see this as a worldwide recognition from our peers.

In this annual report, I invite you to discover ONERA's highlights for 2024. This will be my last editorial, as my term of office expires at the end of 2025, after more than eleven years at the head of an organization that is extraordinary in every aspect.



THE SONDRRA FRENCH-SINGAPOREAN RESEARCH LABORATORY CELEBRATES 20 YEARS - The ceremony, held on 4 April 2024, was attended by : Emmanuel Chiva (DGA), Melvyn Ong (Ministry of Defense and Ministry of National Development, Singapore), Cheong Chee Hoo (DSO National Laboratories, Singapore), Romain Soubeyran (CentraleSupélec), Bruno Sainjon, CEO (ONERA). Supported by a multi-stakeholder alliance, SONDRRA conducts innovative studies in electromagnetism and signal processing.



HEMERIA AND ONERA JOIN FORCES FOR THE SURVEILLANCE OF L'ESPACE - Participating jointly in an increase in ASTAREON's capital, HEMERIA INVEST, the holding company of the HEMERIA group, is providing the funds necessary for the company's development, while ONERA is transferring to it the SSA technologies it has developed. On completion of the transaction, ASTAREON will be 70% owned by HEMERIA and 30% by ONERA, and will be renamed HEMERIA SURVEILLANCE.



ONERA ACCELEROMETERS FOR THE ESA SPACE MISSION
 ESA and ONERA have signed a €27.3 million contract (including €12.5 million in 2024) for the Next Generation Gravity Mission NGGM), for which ONERA will develop and qualify the MicroSTAR accelerometer by 2027. This is further worldwide recognition of ONERA's expertise in the field of ultra-sensitive accelerometry.



INAUGURATION OF THE NEW MODEL WORKSHOP AT THE CENTRE ONERA IN LILLE - On 1st October 2024, ONERA inaugurated its new wind tunnel model workshop in Lille, in the presence of Xavier Bertrand, President of the Hauts-de-France Region, and the press. This workshop, the only one of its kind in the world, demonstrates ONERA's commitment to providing high-precision solutions for the defense and civil aviation sectors.



ONERA ACHIEVES A WORLD FIRST
 In early 2024, ONERA took delivery of the FEELINGS ground station at Fauga-Mauzac centre. On 5 June 2024, FEELINGS established a stable, pre-compensated two-way laser link using adaptive optics (AO) with the TELEO demonstrator in geostationary orbit developed by Airbus Defense and Space. This world first was made possible by AO techniques and high-power lasers developed by ONERA.



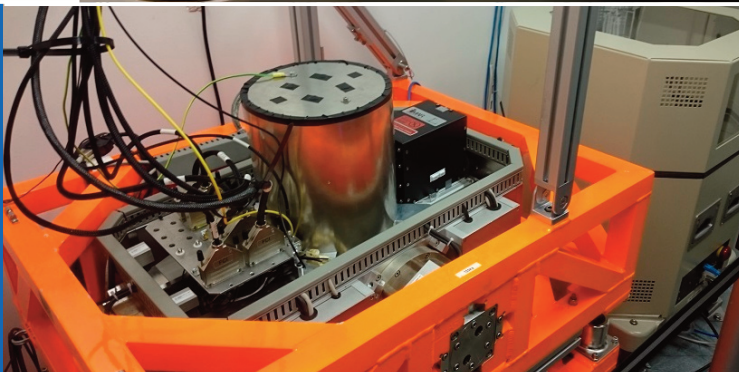
COMBATING UNMANNED AERIAL VEHICLES (LAD): ONERA INVOLVED IN PROTECTION SYSTEMS THE 2024 OLYMPICS! - The French Air Force used ONERA's DIAMOND data fusion module, developed thanks to its expertise in algorithms. This innovative system, which makes it possible to aggregate and merge information transmitted by the various LAD systems, has been used more than a hundred times, and has contributed to the efficiency of the system (many offending drone pilots have been apprehended). ONERA was congratulated by the French Air Force.



IFAR 2024 INTERNATIONAL SUMMIT: ONERA ASSERTS ITS ROLE LEADERSHIP - 15th IFAR (International Forum for Aviation Research) summit, an event bringing together the world's public aeronautics research community, was held in Singapore in October, for the first time under the French presidency. ONERA teams were able to present their work, meet partners and prepare future projects.



ONERA A KEY PLAYER IN THE DISSUASION PROCESS - ONERA has been awarded the MIHYSYS contract by the DGA, in co-contracting with MBDA, to continue improving knowledge of super and hypersonic propulsion. The first ONERA Defense prize, awarded by a jury including the director of the AID and the deputy head of plans/programmes at the EMA, was awarded to a team of 7 scientists involved in the airborne component of deterrence.



ONERA AT THE HEART OF INNOVATION, SERVING THE ARMED FORCES - As a major player in quantum technologies, ONERA has delivered the first cold atom gravimeter to the French Navy, making it the first force in the world to have such equipment. This gravimeter, developed with the support of the DGA and now in operational service, meets all the objectives expected in terms of the quality of the gravimetric measurements (unequaled in a harsh environment), reliability and operational advantage.



DECARBONISATION: SAFRAN AND ONERA JOIN FORCES OPEN FAN DEVELOPMENT - On 19 January 2024, SAFRAN organised a press visit to Modane to coincide with the wind tunnel testing of its Open Fan EcoEngine project. Underlining the challenge represented by such a project, Eric Dalbies, Vice President R&T of the SAFRAN Group, and Pierre Cottenceau, Technical and R&T Director of SAFRAN AE highlighted the know-how and unique experimental resources of the wind tunnel department. SAFRAN AE and ONERA have signed a 5-year partnership agreement governing future wind tunnel tests.

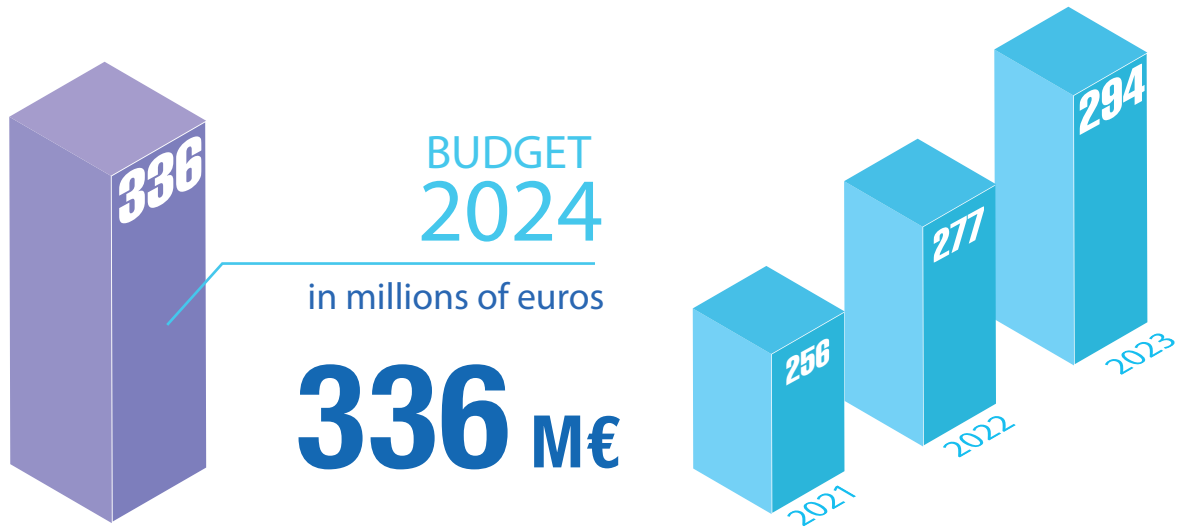


FOURTH CONSECUTIVE RECORD ORDER INTAKE
In 2024, ONERA broke its order intake record once again with €195 million. This new record testifies to the confidence of our national and international partners and the exceptional quality of our scientists, engineers and technicians, both in the scientific departments and the wind tunnels.

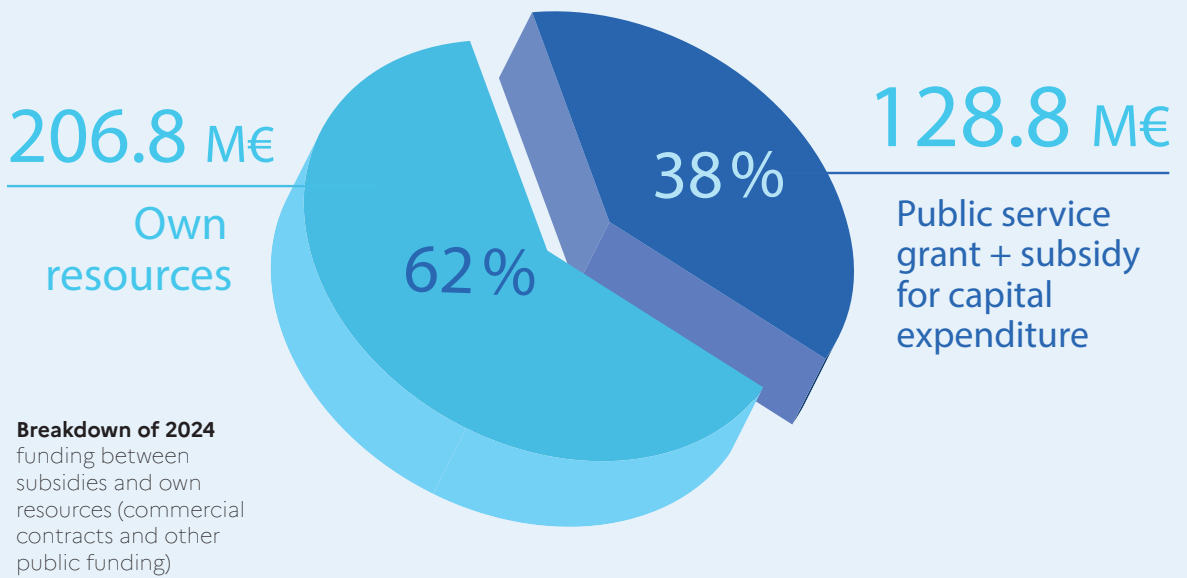


SCIENTIFIC REPUTATION - EREA, the association of European aeronautical research centres, has awarded its prize for the best publication in 2024 to ONERA. This is the 11th time in 15 editions that ONERA has won this prize, a testament to the very high scientific level of its research engineers and their dynamism in terms of publications

RISING BUDGET

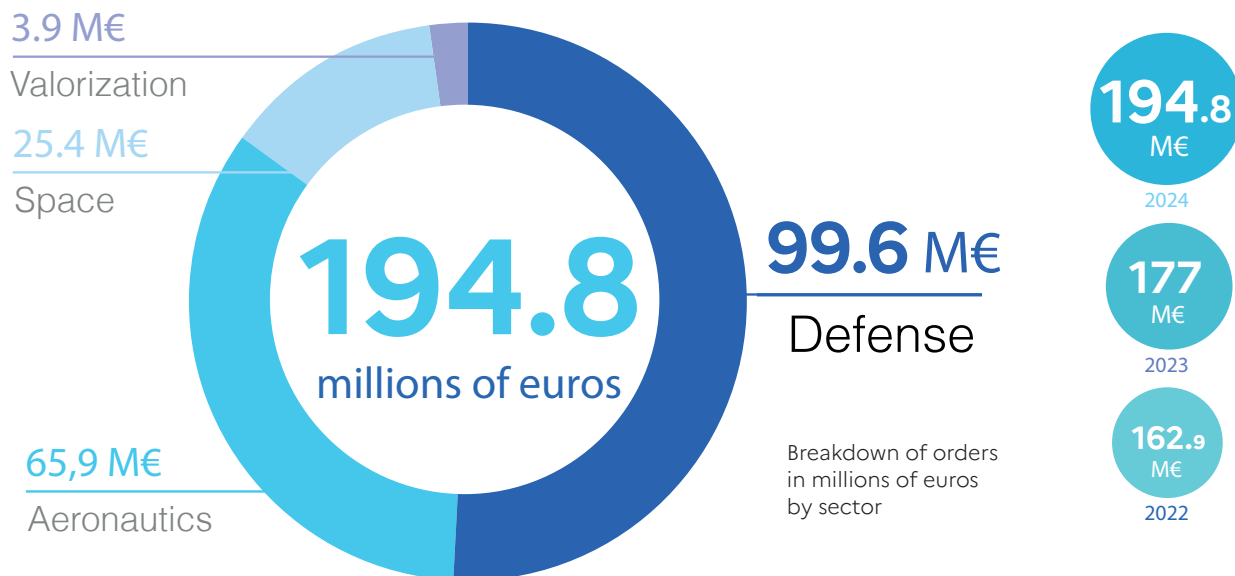


Placed under the supervision of the Ministry of Defense, from which it receives its subsidy, ONERA's budget comes partly from the Defense Innovation Agency and almost 60% from commercial contracts.



NET INCOME : **9.1 M€**

RECORD-BREAKING ORDERS



ORDERS BY SECTOR

51.1%

Defense

Percentage breakdown of order value by field.



33.9%

Aeronautics

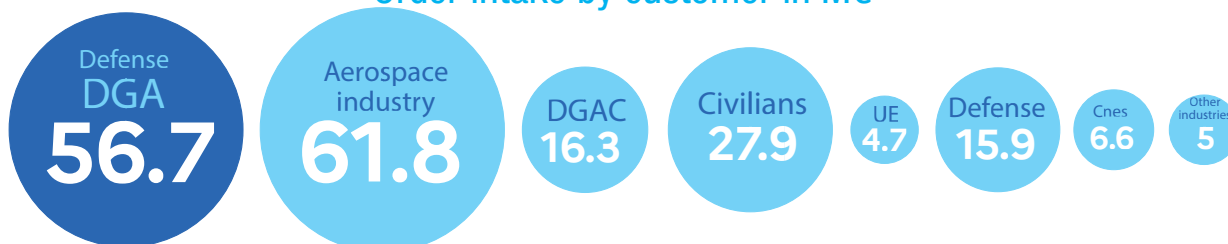
13%

Space

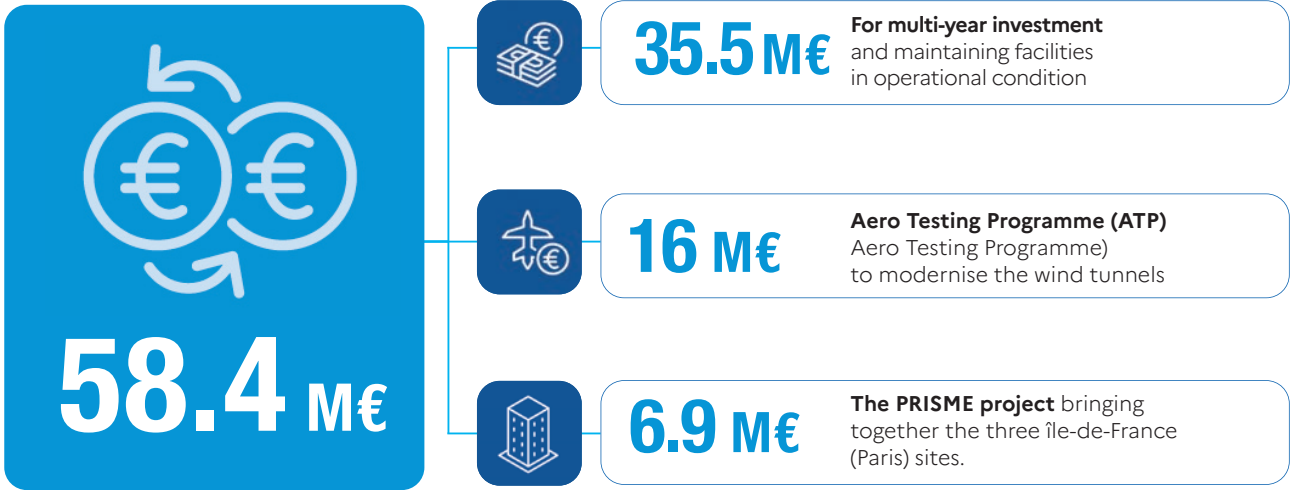
2%

Valorization

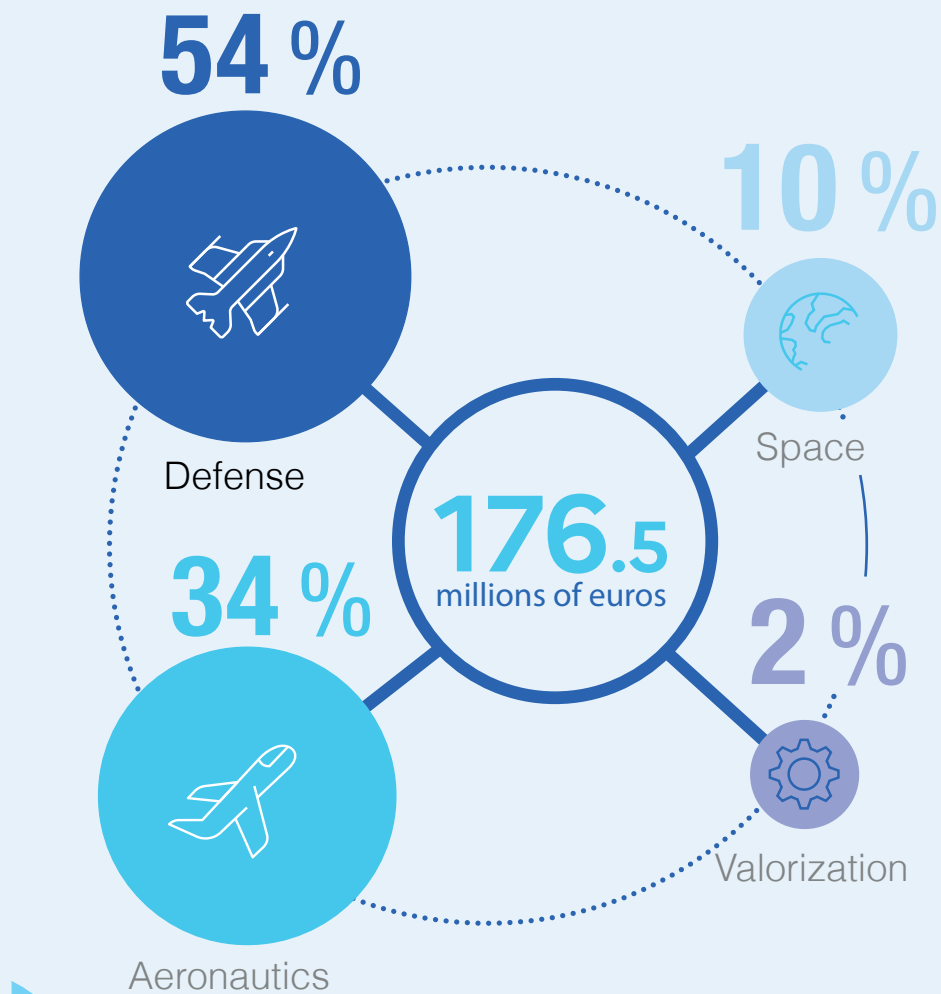
Order intake by customer in M€



INVESTMENTS



DISTRIBUTION OF CONTRACTUAL OPERATIONS BY ACTIVITY



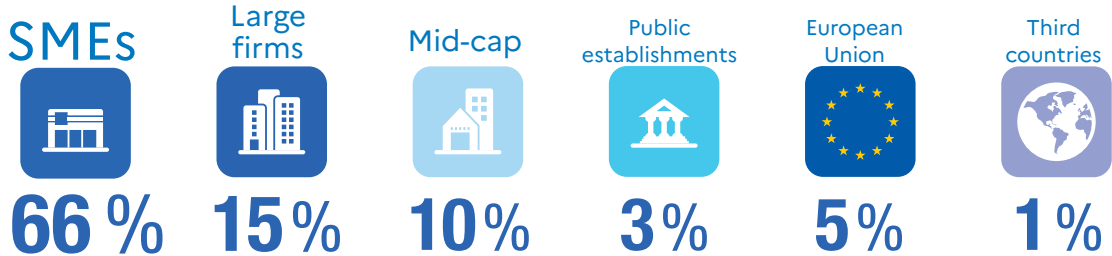
PROCUREMENT

In 2024, ONERA strengthened its policy of support for SMEs, increasing their number to 1964 (compared with 1932 in 2023). These SMEs account for 70% of purchasing actions (orders and contracts), confirming their predominant role in the establishment's purchasing strategy.

Breakdown of purchases by type of business in 2024

The amount of purchases entrusted to SMEs reached a remarkable €82,424k, or 66% of the total (compared with €53,551k and 60% in 2023). This significant increase can be explained in particular by :

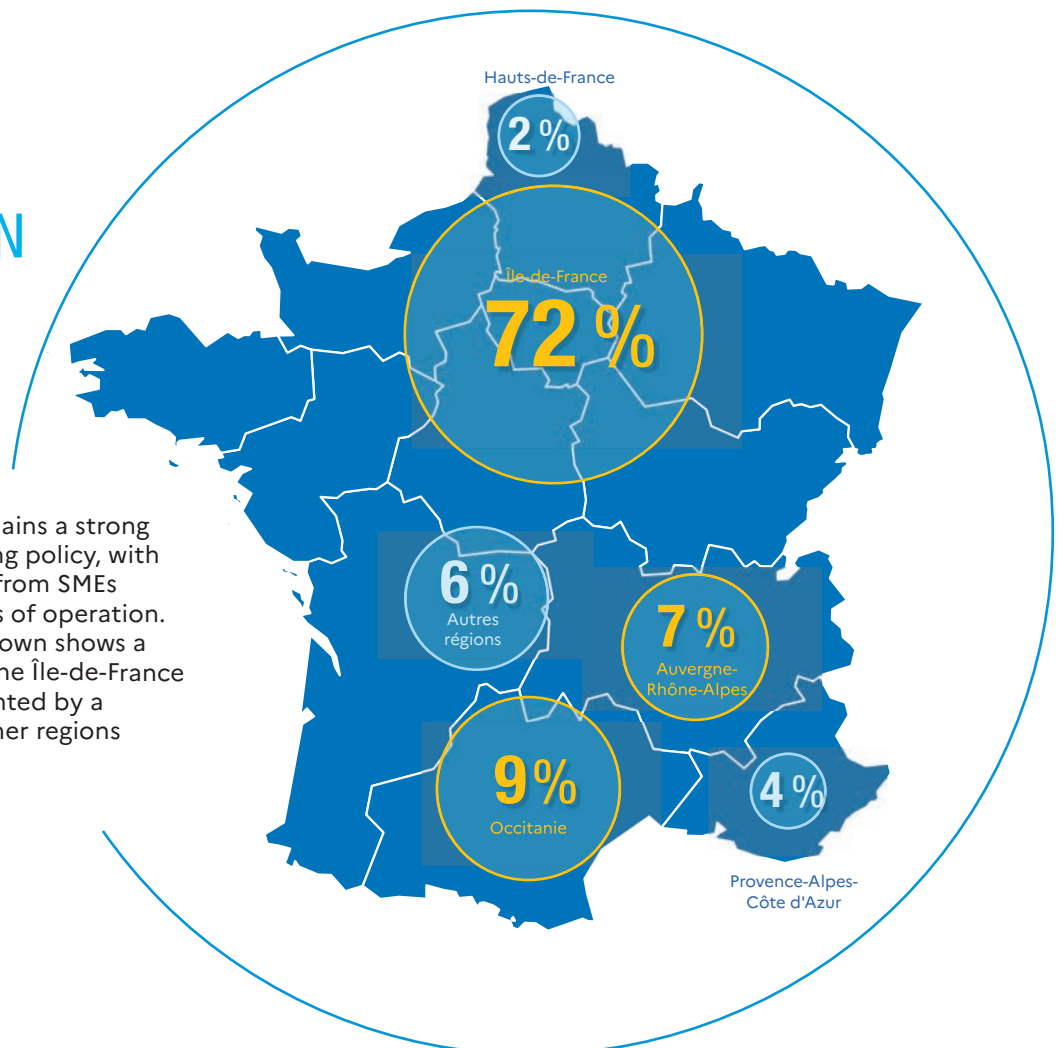
- Strong presence of SMEs in works contracts
- An average contract value of €258K in 2024, adapted to the SME dimension



REGIONAL DISTRIBUTION

of purchases from partner SMEs

Territorial anchoring remains a strong element of the purchasing policy, with 94% of purchases made from SMEs located in ONERA's areas of operation. The geographical breakdown shows a major concentration in the Île-de-France region (72%), complemented by a balanced presence in other regions (between 2% and 9%)





Launch of the new recruitment website

Launched in September 2024, this new website aims to attract and improve the recruitment experience for candidates. Based on video and podcast testimonials from employees, it reflects ONERA's day-to-day work, its employer promise and its five associated values.

ONERA is committed to promoting its employer values: Ambition commune, Engagement, Innovation, Intégrité, Passion et Exigence.

These values, shared by everyone ONERA, were formalised through a collaborative approach in 2023.

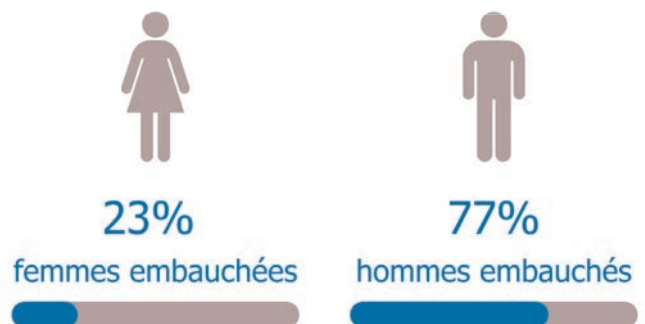
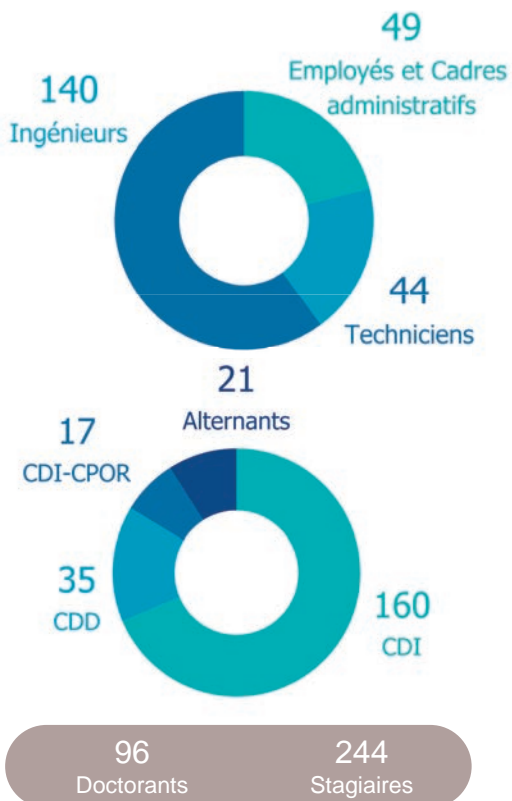
Of course, the site also includes all jobs, theses and internships, as well as information on working life at ONERA and the various career prospects. The lively site will also feature HR news: relations with partner schools, and actions to promote diversity, inclusion and gender equality.

Between its launch and the end of 2024, the site received the visit of 40,000 users, for 75,000 page views



Recruitment in 2024

25 000 APPLICATIONS
233 RECRUITMENTS



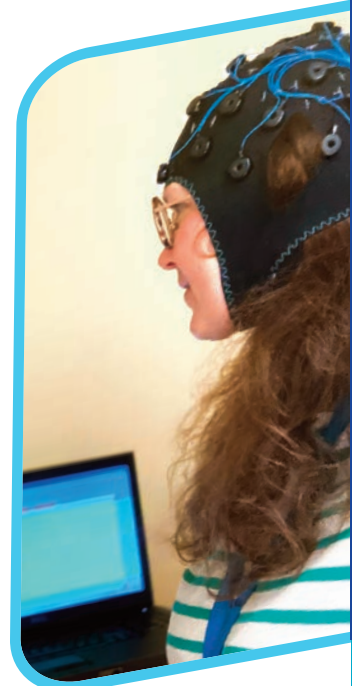
Remaining agile in recruitment: finding atypical profiles

The aerospace sector is changing fast. There are a number of trends and innovations in this field, including artificial intelligence, increasing automation and new safety requirements. All these challenges have one thing in common: the complex relationship man and machine. To tackle these new issues, ONERA knows how to recruit outside its “core business”.

Bertille Somon has this dual background: she began her career by taking the medical entrance exam, obtaining a ranking that enabled her to pursue a degree in biomedical engineering (the only degree of its kind in France).

This dual approach is ideal for joining ICNA (Cognitive Engineering and Applied Neuroscience) team at ONERA in Salon-de-Provence. She explains: "We model the pilot's reactions, through its behaviour, or systems that measure human activity, such as electro-encephalography, MRI or electrocardiography, of which require a high level of expertise. in physiology to carry out these tests and, above all, to understand the data. At the same time, 'm using my other engineering hat to design the experiments and analyse and exploit the results. After her thesis (already completed at ONERA), Bertille began her career at ISAE-SUPAERO. But after being courted by various other laboratories because of the atypical nature of her background and training, Bertille was finally caught up by ONERA: "I had done my PhD there, precisely on this topic of applied cognitive sciences. And since ONERA had opened a position in the unit that had hosted me, we figured on both sides: why not build on my background!"

Today, Bertille is adding to the ranks of this special unit, which has been built up in line with the specific scientific needs it investigates, all centred human-system integration.





2,207 employees

- 1,751 engineers and executives
- 175 employees
- 36 work-study students
- 244 technicians
- 1 worker

26 % dwomen
gender parity index:

95/100

369*
communications
at congresses
with publications

335*
publications in
peer-reviewed
journals

128

scientists with habilitations
to lead research (HDR),
including 6 presented
to juries in 2024

- 377 doctoral students
- 18 post-doctoral students
- 244 trainees

108*
PhD
defended

404*
technical
reports

* Preliminary figures

ONERA Internal Awards: Recognize and Promote

ONERA Defense Award 2024

The ONERA Defense Prize rewards high-level scientific contributions to Defense. It was created specially because the confidentiality of certain work prevented the engineers concerned from competing for other internal ONERA prizes. For this 2024 edition, the jury has chosen to reward the 'Airborne Nuclear Component' team, made up of 7 engineers, who have worked on the preparation of successive generations of our air-breathing strategic supersonic missiles. Proof of our supervisory authority's confidence, the event was attended by a large number of representatives from the French Ministry of Defense, including Vice-Admiral Eric Malbrunot Engineer General of Armaments (IGA) Patrick Aufort, members of the jury, as well as Rear-Admiral Frédéric Dreher and IGAs Cécile Sellier and François-Xavier Dufer



← The winners of the 2024 Dissertation Prize, surrounded by the Management team scientific director of ONERA.

Doctoral students' prize

Each year, this prize rewards the best 3rd year doctoral students in their respective scientific fields :

Fluid Mechanics and Energy: Pierre Hellard - Pierre Hellard - Characterisation experimental and numerical

operation of a rotary detonation combustion chamber.

Materials and Structures:

Loïc Mastromatteo - Development and qualification of an integrated health monitoring (SHM) for launcher revalidation.

Physics: Alessandro de Oliveira Cabral Junior - Design and demonstration of Electronic Beam Scanning Transmitter Array antennae for telecoms applications.

Information Processing and Systems: Kevin Helvig - Multi-sensor learning for non-destructive testing of materials.

Advanced Numerical Simulation: Romain Espoey - Multi-fidelity optimisation under uncertainty, application to the design of aerospace vehicles.

AID 2024 thesis prize

EXCELLENT RECOGNITION FOR THE DOCTORAL TRAINING PROVIDED AT ONERA

Two young ONERA doctors have been awarded the AID 2024 thesis prize. This thesis prize is awarded by the Ministry of the Armed Forces and the Ministry of Higher Education and Research, via the AID. The selection criteria include the originality of the thesis topics proposed, the quality of the work and the potential for future defense applications.

The winners are : **Victor Couty** for his thesis on "Improving characterisation tests for composite materials", and **Denis Langevin** for his thesis on "Controlling light scattering in miniaturised optical devices".

Patrick Aufort (AID Director), Victor Couty, Laurine (recipient outside ONERA), and Denis Langevin →



Nanophotonics: three prizes in the spotlight!

2024 was an excellent year for the Optics and Associated Techniques department, which won three prizes in the field of nanophotonics: ● **Patrick Bouchon**, winner (2023) of the Fabry de Gramont prize for his work in nanophotonics on light-matter interactions in optical nano-antennas for infrared and terahertz, ranging from their understanding physics to optoelectronic applications. ● **Cyprien Brûlon** received the Physics thesis prize from the Université Paris-Saclay. Cyprien Brûlon developed innovative microstructured membranes for detection and imaging in the THz range using infrared cameras. ● **Denis Langevin**, AID thesis prize (see opposite).

General Ferrié Electronics Grand Prix

It was awarded to **Olivier Rabaste** (Electromagnetism and Radar Department). Set up in 1963 and awarded for the first time annually. Olivier Rabaste's work focuses on the detection of weak targets in complex environments in radar applications. Weak targets are targets that are difficult to detect because of their low energy level and/or the complexity of their environment (complex statistical clutter distribution, presence of strong reflectors in the scene, presence of multipaths, etc.).



ONERA 2024 Academy of Sciences Prize awarded to Jérémie Bec

The 2024 "ONERA-Sciences mécaniques pour l'aéronautique et l'aérospatial" prize was awarded to Jérémie Bec, CNRS research director at the Institut de physique de Nice, for his work on fluid turbulence. The prize was officially presented on 26 November 2024 under the aegis of the Institut de France in Paris. Since 2018, the ONERA Prize of the French Academy of Sciences has been awarded to researchers in fluid mechanics and solid mechanics for outstanding work in aeronautics and aerospace. The winner is selected independently by a panel of academics.

Awards

RENÉ MATHURIN, OFFICER IN NATIONAL ORDER OF MERIT

Wednesday 27 November
René Mathurin, Director of
Defense Programmes, has been
made an Officer in National
Order of Merit

RIAD HAIDAR, KNIGHT OF NATIONAL ORDER OF MERIT

Riad Haidar, Chief Scientific
Officer of ONERA, received a
hug from Alain Aspect, winner
of the 2022 Nobel Prize in
Physics, presented him with
the insignia of chevalier
de l'ordre national du
Mérite



René Mathurin



Riad Haidar

BUT ALSO

Mishima Prize awarded to **Mikaël Perrut** (metallic materials) by the SF2M (Société française de métallurgie et de matériaux) - *Medal from the Académie de l'Air et de l'Espace* awarded to **Sébastien Bourdarie** (space environment) - *Prize for scientific excellence* awarded to **Pascale Kanouté** (metallic materials) by the 3AF (Association aéronautique et astronautique de France).

AND FOR YOUNG PEOPLE...

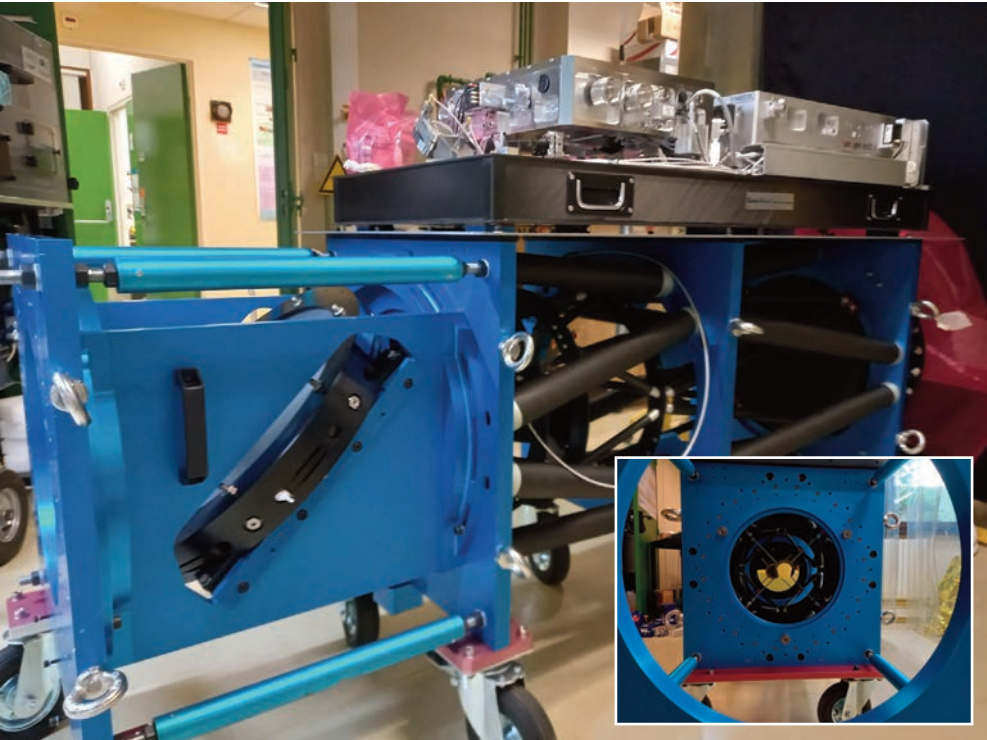
André Blanc-Lapierre Youth Prize awarded to **Mattéo Gouzien** (Information and systems) by the SEE (Société de l'électricité, de l'électronique et des technologies de l'information et de la communication). - *Thesis prize* awarded to **Paul Saves** (applied mathematics) by the Fondation ISAE-Supaero. - *Thesis prize* awarded to **Sébastien Garcia** (fluid dynamics) by the ISAE-Supaero Foundation.

HIGHLIGHTS

2024

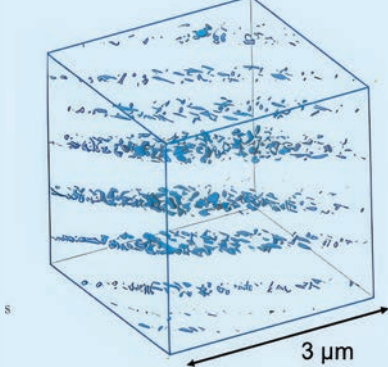
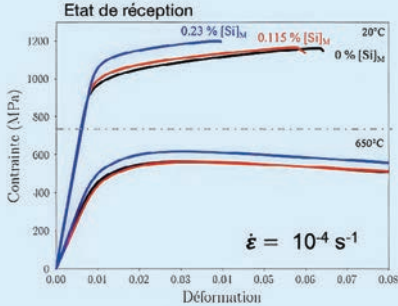
Greenhouse gases : Innovative laser source for DIAL lidar detection

The Horizon 2020 LEMON project, coordinated ONERA, with 8 partners (KTH, Innolas, Fraunhofer ILT, SpaceTech, CNRS, University of Bergen, L-U) has enabled the maturation of lidar technologies for space, particularly in ONERA's field of excellence of parametric sources, by combining innovative source architectures and non-linear crystals that break with the state of art, which have been tested in a space environment. Measurement campaigns with the WAVIL ANR multi-species DIAL lidar instrument have opened up new perspectives for atmospheric physics and meteorology. A more robust multi-species DIAL lidar instrument has been produced and tested. These major advances consolidate ONERA's position in the field and their application to the detection of gases by lidar, in particular the preparation of future Earth observation space missions.



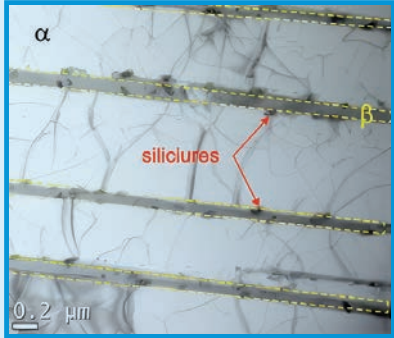
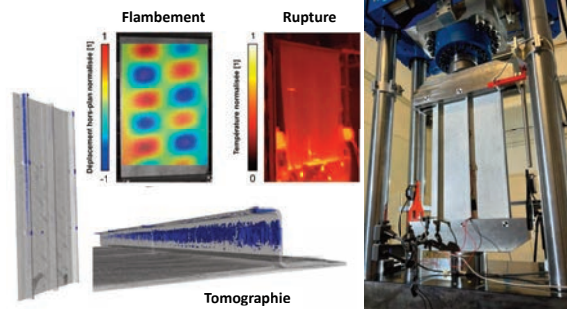
Materials: A high-temperature titanium alloy

Titanium alloys, used engines, turbine components and afterburner structures, cannot be used above 550°C. A new grade of titanium that can be used at temperatures of up to 650°C has been developed as a result of work establishing a direct link between the evolution of the precipitation of silicides of nanometric dimensions and improvement in the material's mechanical properties. This alloy has good resistance to fatigue-flow stresses and good hot mechanical properties, while taking into account interaction with environment, is a major industrial challenge. The work was carried out by ONERA and CNRS as part of the ANR ALTTUDE (nouvel ALiage de Titane hautetempérature pour applications aéronautiques de DEmain), and led to the filing of a patent.



Structures: Tests on composite panels containing manufacturing defects

As part of the PHYDEFECT agreement funded by the DGAC, multi-instrument compression tests on composite panels with manufacturing defects were carried out ONERA in order to characterise the damage and failure of these structures. Results: it is not the number of defects present but rather the way in which they are distributed within the structure that has the greatest influence on its damage and failure. This work contributes to the development of methods for the derogation of composite aeronautical structures containing initial manufacturing defects.

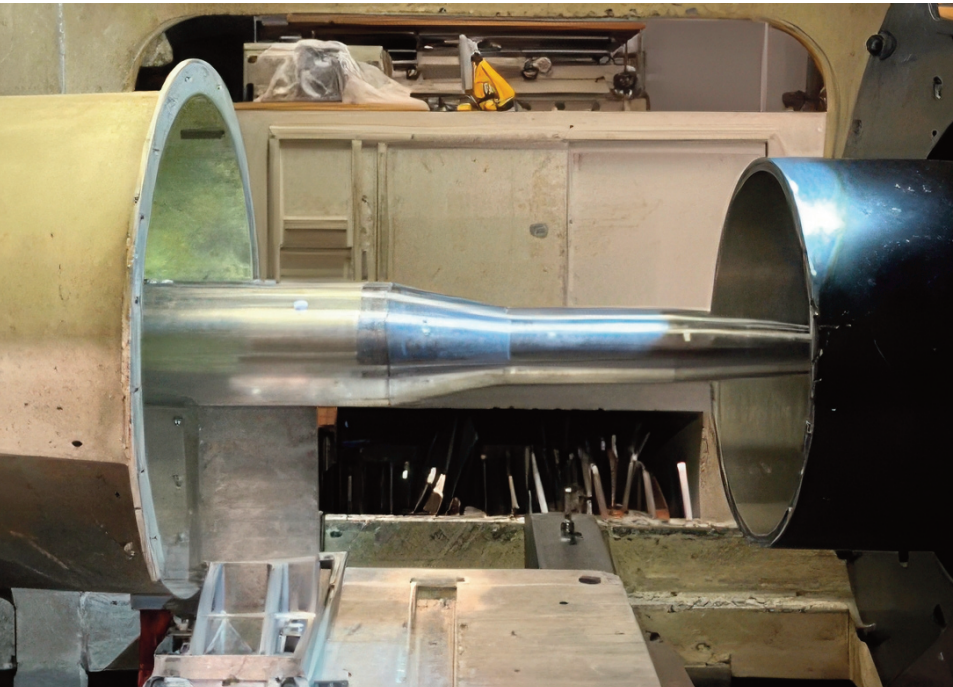


(Top) Stress curves of Ti6244 alloy at 20°C and 650°C as a function of silicon content. (Middle) 3D reconstruction of silicide precipitation by FIB/SEM reconstruction of silicide precipitation by FIB/SEM obtained a METSA measurement campaign at CLYM. (Bottom) MET images showing the arrangement of dislocations in (Ti,Zr)6Si3 precipitates located at the interface between the alpha and beta phases.

Hypersonics: Successful campaign to characterise the laminar/turbulent transition

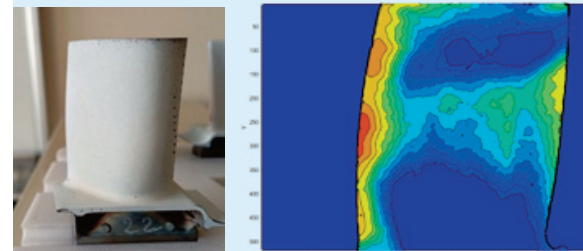
The campaign was used to characterise the laminar/turbulent transition mechanisms on a geometry typical of atmospheric re-entry vehicles. Carried out with CEA-DAM over a two-month period in the R2Ch hypersonic wind tunnel at ONERA Meudon, it enabled data to be acquired on flows at Mach numbers of 6 to 7, which is unprecedented for this type of geometry. These experiments focused on the coupling between the laminar/turbulent transition and the shock/boundary layer interaction at the foot of the skirt. Understanding these dynamics is essential for accurately predicting aerothermal forces during atmospheric re-entry, and hence vehicle trajectories. The CEA and ONERA have developed an experimental set-up based on ONERA's R2Ch wind tunnel experiments (cylinder-skirt, BOLT). Using an ultra-fast camera from CEA-Gramat, stroboscopes of the flow were captured at up to 1.7 million images per second.

CCF12 model in the R2Ch test section.



Turbomachinery: Photoluminescence to test operation at very high temperatures

The ability of engines to operate at increasingly high temperatures is a major competitive advantage. The only solution today for manufacturers to map these temperatures in the engine (up to 900-1200°C) is based on heat-sensitive paints, but a new generation of paint marks a new era: two markers have been deployed for the first time in a photoluminescent paint to reproduce temperature maps on a turbine blade of a Safran Aircraft Engines engine (TURENNE programme). Both markers showed excellent temperature resistance. Imaging analysis confirmed the method's potential: under the effect of temperature, the material's physical properties are irreversibly impacted, making it possible to analyse their post-test photoluminescence once the part has cooled down. The current MARMITHE project aims to optimise the effect obtained and to industrialise the measurement process by transferring technology from ONERA to SHE.



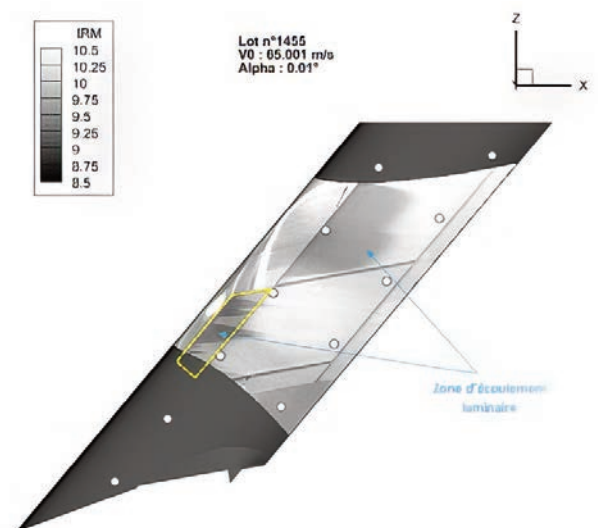
Left: Photograph of the blade covered with the white photoluminescent marker after engine testing. Right: normalised temperature map obtained on the blade.

Aerodynamics: Ultra-fine characterisation of boundary layers as close as possible to rough walls

ONERA has conducted a test campaign to study the dynamics of boundary layers on the surface of a wing roughened by various calibrated coatings. These tests are for validating and improving ONERA's numerical models for predicting friction and parietal heat fluxes on this type of surface, a problem encountered in laminar flow and icing applications. The metrology deployed has made it possible to access data as close as possible to the wall, with a level of detail never before achieved on this type of boundary layer in a three-dimensional configuration. A model of a swept wing profile, heavily instrumented and partially covered with inserts, was installed in the vein. Analysis of the dataset collected will enable us to refine the accuracy of the transition and turbulence models used in industrial applications.



Experimental set-up and laser plan for PIV measurements.



Infrared visualisation of the transition process from laminar boundary layer to turbulence. The position of the rough insert is marked in yellow; the rest of the leading edge of the wing is smooth. Laminar regions are shown in dark grey, turbulent regions in light grey.

Materials: 3D printing of ceramic parts by depositing molten wire

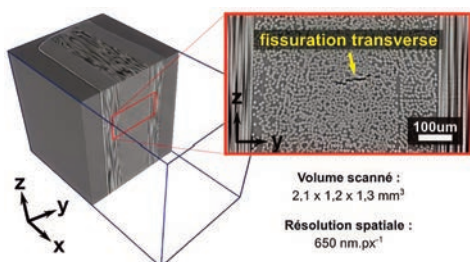
ONERA has succeeded in producing 3D ceramic parts using the FDM (Fused Deposition Modeling) technique, using a machine designed for polymers and ceramic-filled wires. These initial tests are helping assess the potential of the FDM technique, a recent technique that is beginning to be deployed to produce parts for the aerospace and defense industries: radio-frequency windows (or even stealth), actively cooled parts, skeletal structural parts, etc. The tests produced parts of up to 10 cm in size and a wide variety of shapes, impossible to produce using conventional methods. Various characterisations (microstructural, profilometric, mechanical, electromagnetic) will highlight the advantages and shortcomings of this technique.



Alumina part obtained by FDM: a turbine part and a honeycomb sandwich panel (grid: 5x5 mm).

Composites: 3D observations damage to thermoplastic matrix composites.

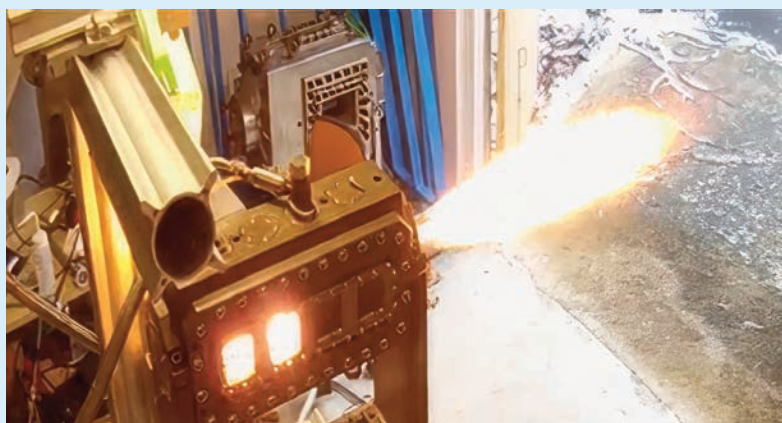
ONERA carried out mechanical tests on the ANATOMIX line of the Soleil synchrotron to study a new composite material, made up of carbon fibres and a thermoplastic matrix. The tests revealed a high density of microcracks in the folds of the specimens, thanks to the high resolution of the tomographic observations. The results will be used to validate ONERA's mechanical behaviour models for these materials, based diffuse damage models. They offer good performance, particularly in terms of weldability and recyclability, and are being considered for future civil aircraft fuselages. Their use will depend on the understanding and characterisation of their damage, an area in which ONERA is continuing its research.



Evidence of microcracks during tests at the Soleil synchrotron.

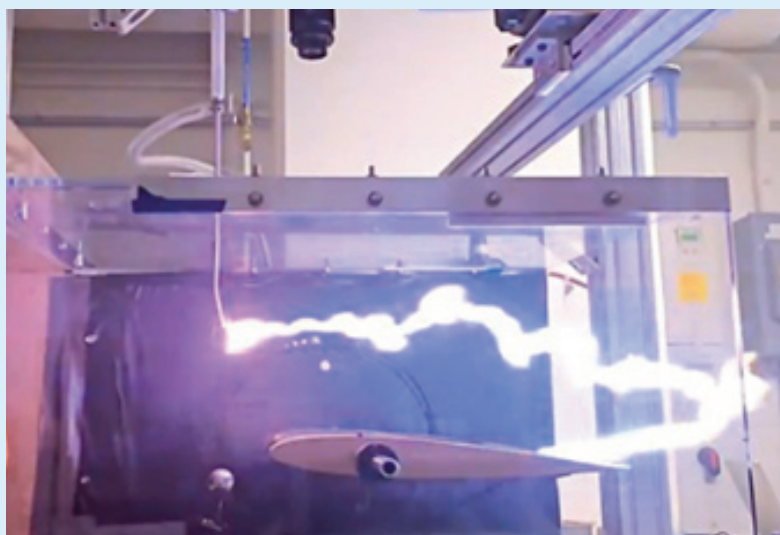
Combustion: New test bench for ignition a solid propellant engine

ONERA has developed the PUMAS bench, dedicated to the study of the isobaric propagation of an ignition front on the surface of a solid propellant plate ignited in a controlled manner using a high-power infrared laser. The chamber is extensively instrumented thanks to the many access points and portholes available, enabling the simultaneous implementation of various optical diagnostics and pressure and heat flux measurements. With its simplified geometry, this set-up will make it easier to develop models and validate them with ONERA's CEDRE software platform (digital for energy), while coming closer to conditions representative of real engines: pressure, temperature and chemical composition. This bench, financed by the DGA, will enable us to better understand and model the ignition phase of a solid propellant, which is a critical phase for these engines in both space and military applications.



Aeronautics: Successful wind tunnel experiment with a lightning strike on wing profile

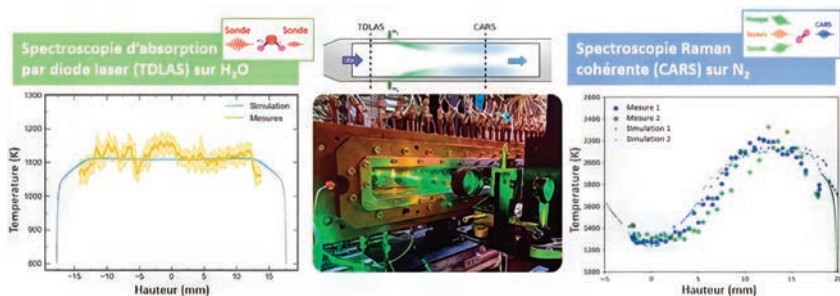
A campaign wind tunnel tests was carried out with the aim of finely characterising the interaction an electric arc, simulating lightning, with the flow around a wing, in order to understand and validate the movement of the foot of the arc on the surface of the aircraft, a condition representative of the reality an aircraft in flight impacted by lightning. The originality of this test lies in the fact that it takes into account the airflow around the airfoil. This campaign is the result of collaboration with MIT in Boston and the Universitat Politècnica de Catalunya. ONERA designed the experiment, a success that has generated a large volume of experimental data is currently being . This data is essential for understanding the physics involved, and also provides a reference base for validating the numerical models developed at ONERA.



Wind tunnel and test section instrumented with laser and camera for PIV and NACA12 wing profile.

Ramjet: Validation of 2 in situ laser diagnostic techniques on a test bench

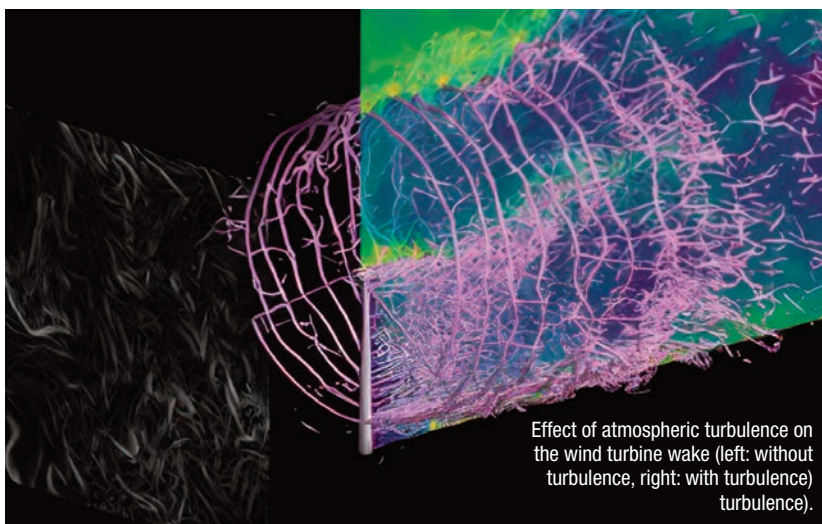
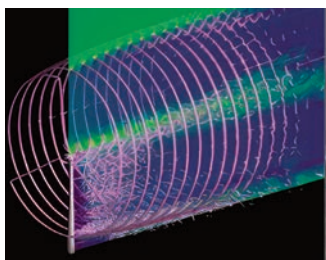
A measurement campaign was successfully carried out for EASSM SECHMET upstream study programme, combining several advanced laser metrology techniques in a reactive supersonic flow. Two in-situ spectroscopy techniques were deployed: TDLAS (tunable laser diode absorption), which provides measurements of temperature and species concentration (H_2O), and CARS (coherent anti-Stokes Raman scattering), which allows measurements. In particular, these new measurements have made it possible to characterise the flow upstream of the chamber and refine the input conditions for the model's digital simulations, as well as highlighting the relevance of certain models. They validate the use of these two techniques to diagnose supersonic flows and place ONERA's metrological expertise in these demanding environments at the cutting.



Vertical temperature profiles obtained by CARS and TDLAS upstream and downstream of the injectors in supersonic hydrogen/air combustion.

Energy transition: Effect of atmospheric turbulence on a wind turbine

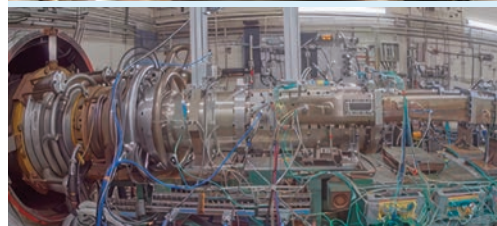
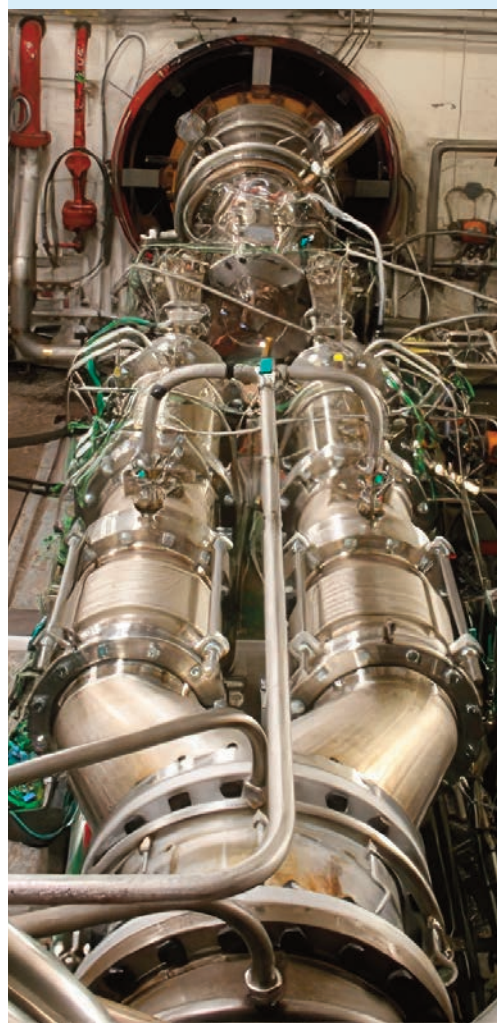
For the first time, ONERA has carried out a simulation of the impact of atmospheric turbulence on a wind turbine's energy production, as part of the International Energy Agency's international cooperation programme. This turbulence reduces the power the wind turbine can produce and can cause vibrations that can lead to premature fatigue or even failure. Unsteady-state simulation takes account of this turbulence by introducing a new, more accurate and more accurate model of the wind turbine. The model requires a high degree of accuracy to model both the moving blades and the vortex wake. The model, which requires a high degree of accuracy to model both the moving blades and the vortex wake, uses 770 million points. This process, carried out using ONERA's FAST code, simulates more than 20 revolutions of the rotor. The results provide a better understanding of these phenomena and enable faster models to be created. It also demonstrates ONERA's ability to apply its aerospace tools to renewable energies.



Effect of atmospheric turbulence on the wind turbine wake (left: without turbulence, right: with turbulence).

First endurance test very high throughput

ONERA has successfully tested the operation a jet engine combustion chamber, in conditions at the limits of its facilities' capabilities and over a period never before achieved. The ramjet engine, designed by ONERA using the know-how acquired during previous tests and the capabilities of the CEDRE calculation code, performed optimally under severe endurance conditions. This work is making a major contribution to the development of air-breathing engines for the air-borne component of the deterrent.



Combustion chamber ready for testing on the test bench of the Multi-Physics for Energy department in Palaiseau.

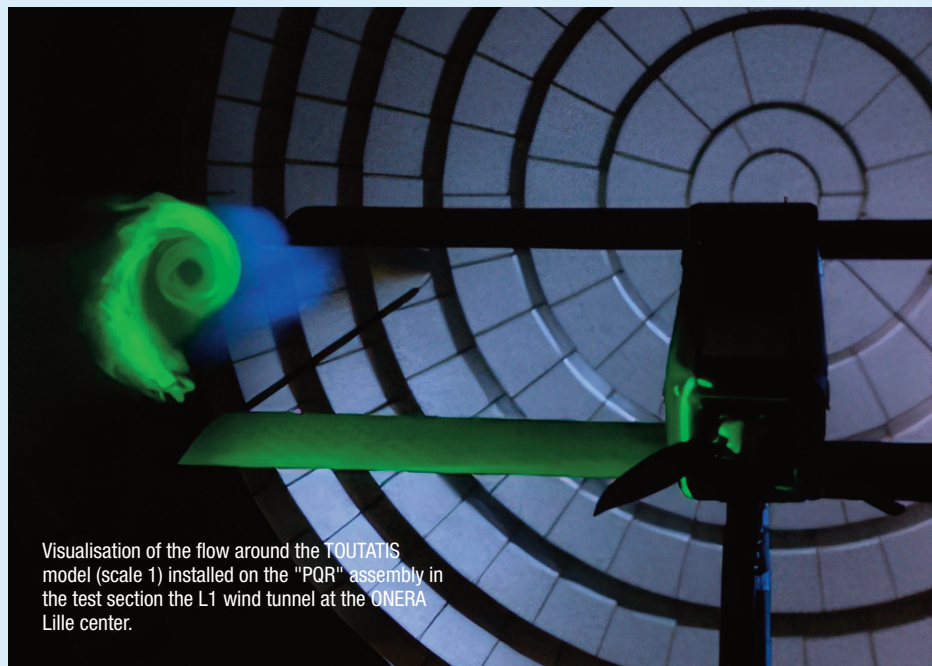
Aviation safety : A new bench for testing wear on materials

A new abrasion test bench has been inaugurated at the ONERA centre in Lille. Financed under the PHYSAFE 2 DGAC agreement, it has received support from the NextGeneration EU and France Relance programmes. It will enable the study of wear and heating of aeronautical materials emergency landings when the landing gear is retracted.

In an emergency landing, an aircraft lands "on its belly" and slides along the ground. Certain structural components, such as fuselage, engines and other dedicated components, can be subjected to extreme mechanical and thermal stresses caused by friction on the runway. The operating principle of the test rig is based on an existing tribology rig used by the University of Lille (LaMcube) to study high-energy braking systems.



Drone: Dynamic characterisation of the propulsion effects of a remotely piloted munition



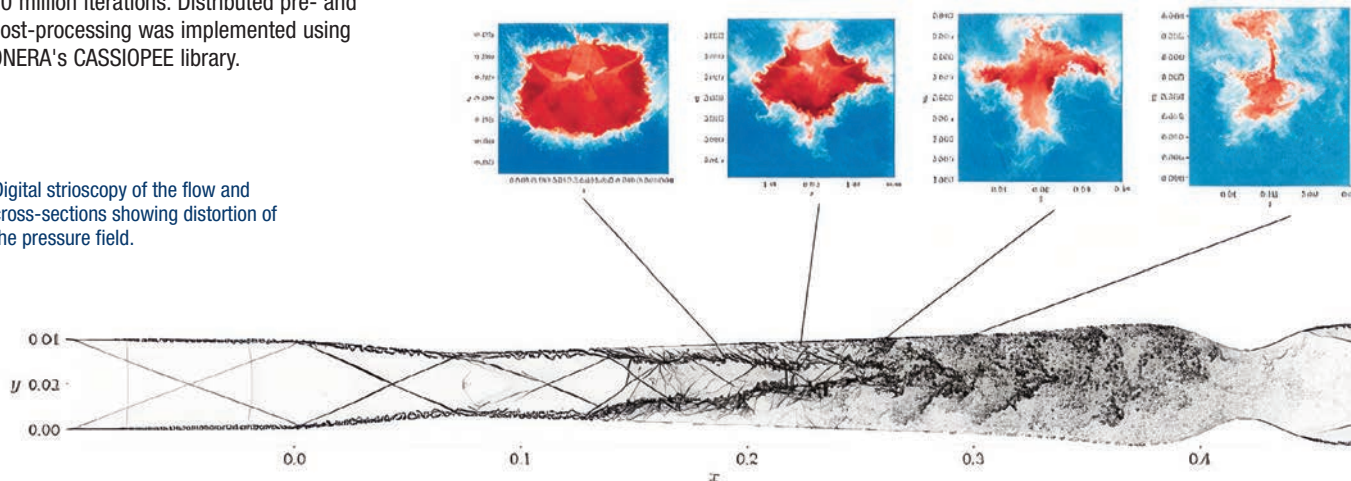
Visualisation of the flow around the TOUTATIS model (scale 1) installed on the "PQR" assembly in the test section the L1 wind tunnel at the ONERA Lille center.

Tests to characterise the static and dynamic behaviour of the Thales TOUTATIS UAV were carried out in the L1 wind tunnel at the ONERA centre in Lille on a model. This remotely operated MTO munition, currently under development, is equipped tandem wings and a propulsive propeller. The most original aspect of this study was the inclusion of the effects of propulsion in the aerodynamic model: the model, equipped with its propulsion system, was placed on the 'PQR assembly (assembly with three degrees of rotation around the model axes) in order to carry out these tests.

Numerical simulation: Improving the modelling of turbulence in aerobic vehicles

Predicting the propulsive efficiency of aerobic hypersonic vehicles involves calculating the flow in the duct upstream of the ramjet, which is a major challenge for traditional turbulence modelling techniques. A representative test case was created for the different models. A boundary simulation was then carried out using GENCI resources provide a reference solution. This calculation (direct numerical simulation), which directly solves the Navier-Stokes equations without having to resort to turbulence modelling, was carried out on a mesh of 3.8 billion points with ONERA's FASTS solver for a calculated physical time of 3 ms in 10 million iterations. Distributed pre- and post-processing was implemented using ONERA's CASSIOPEE library.

Digital strioscopy of the flow and cross-sections showing distortion of the pressure field.



DEFENSE



SPACE SURVEILLANCE

HEMERIA and ONERA join forces to monitor Space

An increase in ASTAREON's capital will make this alliance a reality. Created in 2023 by ONERA, ASTAREON will leverage ONERA's SSA technologies to meet the growing challenges of space security, and offer services in this field. Now 70% owned by HEMERIA and 30% by ONERA, the company has been renamed HEMERIA SURVEILLANCE.

In May 2023, ONERA set up its first subsidiary, ASTAREON, to leverage its historic expertise in space surveillance, which is unique in Europe and was acquired thanks to the GRAVES system. The renovation and performance upgrade of this system, which has been in operational service with the French Air Force since 2005, is currently in the final stages of completion.



The MEDOC radar station.

ONERA at the heart of the French military space



The fourth edition of the French military space exercise AsterX was held from 29 February to 15 March 2024.

For the past four years, ONERA has been providing the Space Commission with its expertise in the field of space surveillance as part of AsterX exercise. ONERA is responsible for simulating all the surveillance resources involved (surveillance and tracking radar, telescopes, radio frequency sensors), with direct interaction with state and industrial partners. To do this, ONERA relies on its s4 calculation code, which it has been developing since 2000.

ONERA also guarantees the representativeness of the scenarios proposed to the various players by ensuring the production of the space situation rendered by the GRAVES system (designed and produced by ONERA and operated by the French Air Force) throughout exercise. Its expertise enables it to adapt to changes in the scenarios defined by the participants.



Notification of the MIHYSYS contract

In 2024, ONERA was awarded the MIHYSYS contract by the DGA, in co-contracting with MBDA. It will enable us to continue improving our knowledge, forecasting resources and technological building blocks, including alternative ones, for the combustion chambers of supersonic and hypersonic air-breathing thrusters. This is a major long-term contribution by ONERA to the airborne nuclear component

The programme includes

- to carry out new experiments on ramjets and statomix engines in order to observe the physical phenomena involved in the performance of these types of engine,
- to develop measurement resources adapted to observation of these phenomena and to the study of ramjet and statomixed propulsion,
- to participate in the development of new capabilities and new models for the numerical simulation of combustion chambers with the CEDRE calculation code, made available to MBDA teams, based in particular on ex-ante studies.

and those of the current market,

- study new technological building blocks that could be used for future high-speed aerobic propulsion,
- Evaluate and develop quantum computing capabilities, with considerable breakthrough potential, for fluid mechanics and energy.

This 5-year contract, worth more than 30 million euros (ONERA share), is a continuation of the EASSM-SECHMET contract, which already had similar objectives. ONERA thus remains a key player in the field of airborne components.

HYPERSONICS AND COMBAT AVIATION

SUPERMAN : Aerodynamic phenomena in high-impact flight

The SUPERMAN research project, which began in 2021 and will be completed in 2024, has enabled us to refine our understanding of the following phenomena in particular **The physics behind the appearance and development of vortices in the extrados of modern fighter aircraft wings.** The comparison of results obtained during tests in the Lille wind tunnels (weighing, Particle Image Velocimetry, etc.) with aerodynamic calculations increased confidence in the methods used in the numerical simulations.

This project has inspired the COBRA (2024-2025) federating research theme (ARF), which aims to carry out a multidisciplinary optimisation of the shape of a combat aircraft, and the DYNVOL research project which, for part of its scope, extends the work of SUPERMAN on the generation of flight dynamics models. The COBRA ARF (2024-2025) is based on the work of the Aerodynamics, Aeroelasticity, Acoustics, Electromagnetism and Radar, and Information Processing and Systems departments, in order to design a geometric shape that is proprietary to ONERA using so-called "high-fidelity" approaches. Initially, the impact of the shape of the nozzles and air inlets on the overall radar signature of an aircraft is quantified.



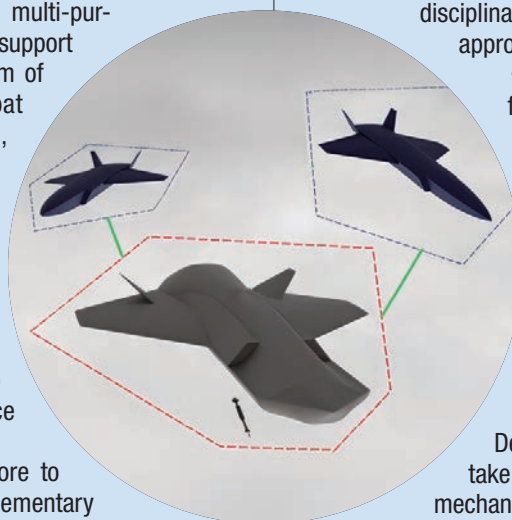
Mach number field around an example of a configuration studied as part of the COBRA ARF, using RANS calculations carried out with SoNICS

PHOBOS: Multidisciplinary modelling of combat UAVs

The aim of the PHOBOS federative research project is to develop a set of methodologies for the design of collaborative combat UAVs to accompany future-generation fighters and operate in the operational context a future air force system, as envisaged in the SCAF (Système de Combat Aérien du Futur) programme.

These aircraft are envisaged as multi-purpose, multi-functional platforms to support manned fighter aircraft, with the aim of transforming conventional combat aviation. These innovative UAVs, which may have several levels of autonomy and are somewhere between a cruise missile and a droned fighter aircraft, promise to open up a huge range of operational possibilities and could take part in a very broad spectrum of missions: e.g. area defense, aerial hunting, deep strikes, intelligence and surveillance missions, target acquisition, etc.

The aim of this project is therefore to bring out new, modular and complementary configurations (i.e. complementarity between UAVs and with the other systems of a future combat cloud), and to develop methodologies and tools for the multidisciplinary optimisation of future combat platforms adapted to their operational environment.



Numerous methodological development activities,

The aim is to design collaborative heterogeneous UAVs that maximise the operational success of a future force system in tactical situations inspired by the needs of the SCAF.

To this end, ONERA is developing new design tools adapted to the study a wide range of UAV configurations via :

- The use of new digital optimisation in the field of co-design
- Multi-disciplinary modelling of a heterogeneous fleet of combat UAVs based on the implementation of a multi-disciplinary, two-level, systems-oriented design approach system of systems

- Mathematical modelling of the design features associated with the project's UAV specifications. These design features will correspond to the needs associated with systems belonging to the first circle of an SCAF: survivability, manoeuvrability, agility, modularity, versatility and adaptation potential, to deal with current and future threats (not necessarily known at the time of design). ONERA is therefore proposing to adapt a Multidisciplinary Design & Optimization (MDO) approach to take into account algorithmic diversification mechanisms, 'system of systems' and CONOPS (concept of operations) management aspects of a heterogeneous fleet, new 'objective' functions (e.g. platform acquisition cost, etc.) as well as disciplines rarely integrated during the concept exploration and preliminary optimization phases (e.g. radar signatures).

MUNITIONS

ONERA AND KNDS JOIN FORCES TO INCREASE THE RANGE OF ARTILLERY AMMUNITION

The EC3B contract (Study on improvement of the methodology for the aeroballistic characterisation of Base Bleed) awarded by the DGA to ONERA and KNDS Ammo France, aims to improve understanding of the phenomena and modelling of the Base Bleed effect and pyrotechnic devices that increase the range of artillery shells.

Begun in 2019, the project has just passed a major milestone: the development a means of characterising these devices.

ONERA has extended its CEDRE energy



calculation code to take into account Base Bleed operating conditions and has designed a test . It has just carried out tests at unprecedented propellant rotation speeds of up to 12,000 rpm. This unique test will make it pos-

sible to study precisely the MUNITIONS

Base Bleed simulates the use a munition in realistic conditions (rotation speed, altitude, etc.).The EC3B study also aims to improve the performance of these devices.

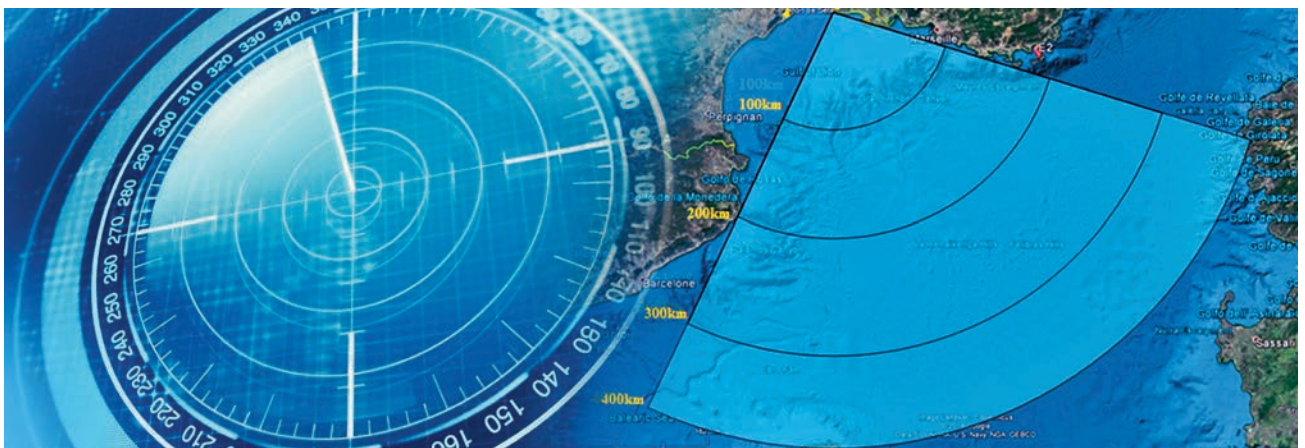
European defense : ONERA, technical coordinator of the iFURTHER project



After 18 months of activity, the iFURTHER consortium presented the progress of its work to the European Commission at a workshop held in May at Warsaw University of Technology.

This project, financed by the European Defense Fund (EDF) and led by HAI (Hellenic Aerospace Industry), with ONERA providing technical coordination, brings together 17 partners. Its ambition is to develop a co-operative

network trans-horizon HF radars and reception nodes to be deployed throughout Europe and at its borders. This system of systems should eventually provide a surveillance capability over the whole of the Union's territory and an early warning function. As part of this study, ONERA is implementing the NOSTRADAMUS trans-horizon radar and developing an HF reception node which will be deployed in 2025 in Crete evaluate hybrid modes, combining skywave and surface wave propagations. A general presentation of the iFURTHER concept is now available in a video produced for the consortium.



EURONAVAL 2024: ONERA unveils the new generation ROS

At EURONAVAL 2024, ONERA is unveiling the latest version of its trans-horizon radar demonstrator on the stand of the French Ministry of Defense.

ONERA, with the support of the AID and the DGA, is taking a new step forward in the field of maritime surveillance with the ROS NG, capable of detecting maritime targets up to several hundred kilometres away.

The fruit of more than 20 years expertise, this radar incorporates breakthrough technologies to deliver exceptional performance in the detection of small maritime targets. evaluations, funded by the DGA, are scheduled over the coming months explore the performance of the ROS NG in greater depth.

AIR DEFENSE



Operations very high altitude

The updating of work on the ONERA NOSTRADAMUS transhorizon radar offers the opportunity of a secure detection capability at very high altitudes (above 20 km). This trans-horizon radar concept has a European application through the I-FURTHER EDF, to which ONERA is contributing. A general presentation of the iFURTHER concept is now available in a video produced by the consortium.

European Defense Fund 2024: another excellent harvest for ONERA

Out of 11 projects submitted in 2023, in which ONERA is participating, 7 projects have been accepted in 2024 by the European Commission. With a budget of €7.9 billion for the period 2021-2027, the European Defense Fund supports transnational projects in the European defense sector. The aim is to strengthen the competitiveness and innovation of European defense. This is proof of the key role that ONERA plays in supporting defense industry (MBDA, Naval Group and Thales in particular), for which it uses its expertise in the fields of radar, optics, aerodynamics and information processing, among others.

DRONE WARFARE : ONERA AT THE HEART OF SECURITY FOR THE 2024 OLYMPICS AND THE INAUGURATION OF THE REOPENING OF THE AIRPORT NOTRE-DAME DE PARIS CATHEDRAL

ONERA had an operational success during the security measures for the Paris 2024 Olympic Games, with its Diamond runway fusion module included in the SAP software (shared air situation). Current developments in artificial intelligence will increase the functionalities of LAD command and control centres tenfold.

ONERA is successfully continuing its work on passive radar for drone detection in conjunction with the French Air Forces military air experimentation centre (CEAM).

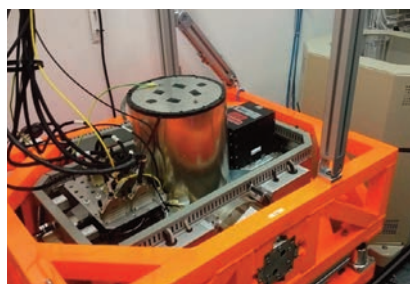
In terms of optronics and lasers, ONERA is successfully maturing technologies such as LIDAR and lasers in the field of anti-drone warfare, with applications for the protection of fixed or mobile units

QUANTUM

ONERA delivers its quantum gravimeters to the DGA

Following the contract awarded by the DGA in September 2020 for the development and supply of GIRAFE gravimeters (on-board interferometric cold atom research), ONERA has delivered and accepted a first operational system in 2024

Following the development of cold atom absolute marine gravimeter demonstrators, ONERA has delivered an operational version of the system. Its appeal lies in its innovative quantum technology also makes it much



more accurate than conventional systems. Its innovative quantum technology also makes it much more accurate than conventional systems.

Thanks to a grant from the French Ministry of , ONERA began investing in the field of atomic gravimetry more than 15 years ago, and has benefited upstream research contracts from the DGA since 2006. Thanks to these investments, ONERA has developed demonstrators of a cold atom absolute marine gravimeter, called GIRAFE 1 and 2. The industrialisation of this innovative prototype has been carried out under ONERA's responsibility in recent years, in close collaboration with EXAIL. ONERA may be asked to order 3 other systems.

AERONAUTICS



REDUCED ENVIRONMENTAL IMPACT

AWATAR : technological building blocks for a promising aircraft concept

The efficiency of aircraft and engines is one of the key levers for reducing environmental impact: to accelerate the arrival ultra-efficient SMR aircraft, the AWATAR (Advanced Wing MATuration And integRation) project of the European CLEAN AVIATION partnership aims to develop technological building blocks for future aircraft concepts. Launched on 1st January 2024, under the leadership of

ONERA, AWATAR aims to bring an ambitious aircraft concept to fruition: a very high aspect ratio shrouded wing architecture with laminar airfoils for the outer part of the wings, integrated de-icing systems compatible with laminarity, and optimised integration a USF (Unducted Single Fan or open-fan) engine. The research is based on high-fidelity numerical simulations, wind tunnel tests and a ground demonstrator.

The AWATAR consortium brings together industrial partners, including Airbus, Dassault Aviation and Collins Aerospace, 4 research establishments (ONERA, DLR, NLR and ETW) and two university partners (TU Delft and Université de Montpellier). To ensure the certification of these tech-



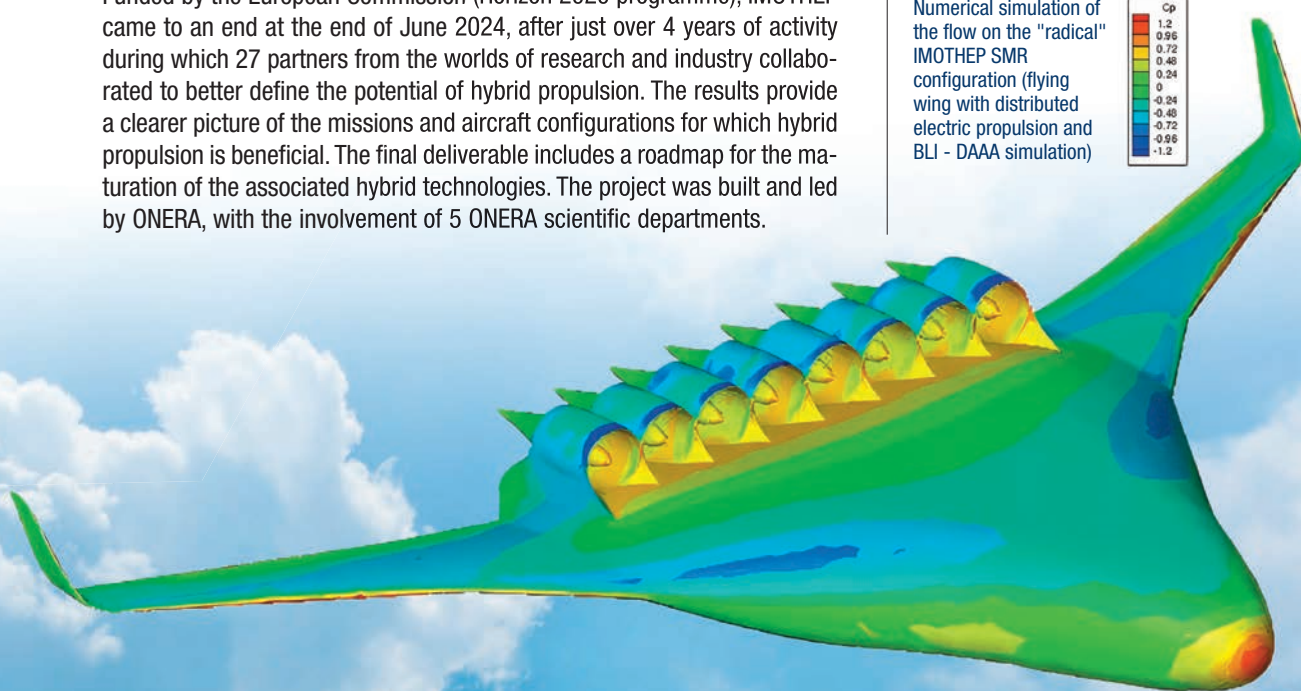
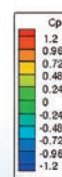
Innovations in the AWATAR project: shrouded wings, laminar wings and open-fan engines.

nologies, EASA will be involved and will evaluate the results of the project. AWATAR will establish links with related projects within the CLEAN AVIATION partnership, including UPWING, ACAP and CONCERTO, in which ONERA also participates.

Hybrid electric propulsion: Final workshop for the European IMOTHEP consortium

Funded by the European Commission (Horizon 2020 programme), IMOTHEP came to an end at the end of June 2024, after just over 4 years of activity during which 27 partners from the worlds of research and industry collaborated to better define the potential of hybrid propulsion. The results provide a clearer picture of the missions and aircraft configurations for which hybrid propulsion is beneficial. The final deliverable includes a roadmap for the maturation of the associated hybrid technologies. The project was built and led by ONERA, with the involvement of 5 ONERA scientific departments.

Numerical simulation of the flow on the "radical" IMOTHEP SMR configuration (flying wing with distributed electric propulsion and BLI - DAAA simulation)



AIR TRAFFIC MANAGEMENT

Artificial intelligence: Preparing for the operational launch of SINAPS, an air traffic control management support tool.

As part of the agreement signed in 2023 between ONERA and the DSNA for operational use of SINAPS in French en-route control centres, the teams have been working on preparing for the operational launch. , the transition from experimental software to operational software requires in-depth technical work (version upgrades, IT security, definition of degraded modes, etc.), ... and documentary work. This project was launched in close collaboration between ONERA and the DSNA, in parallel with continuation of SESAR experiments to prepare for



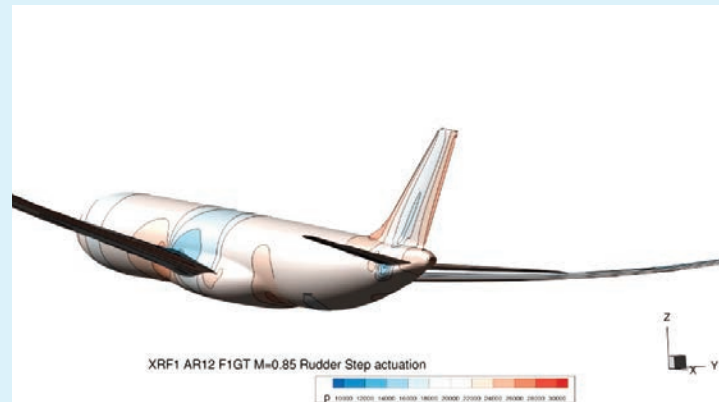
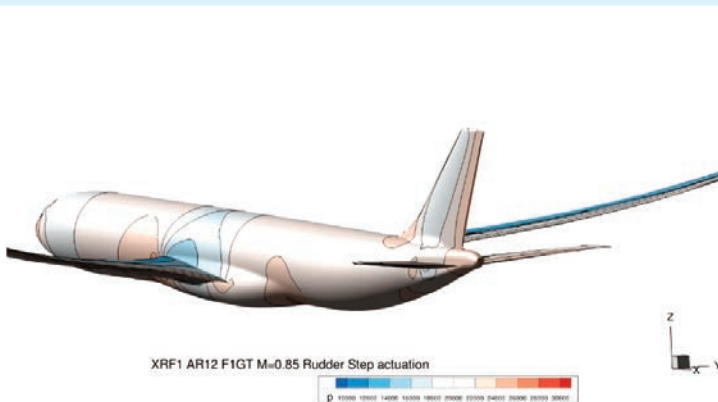
the future and launch of studies with the air traffic control centres to take account of their specific characteristics. The system is expected to be operational by the end of 2025, with the north-east air navigation service centre (Reims) as the pilot centre.

SINAPS provides an exploded view of the elementary sectors of French airspace, which are grouped together into control sectors as the day progresses.

CERTIFICATION AND NEW TESTING RESOURCES

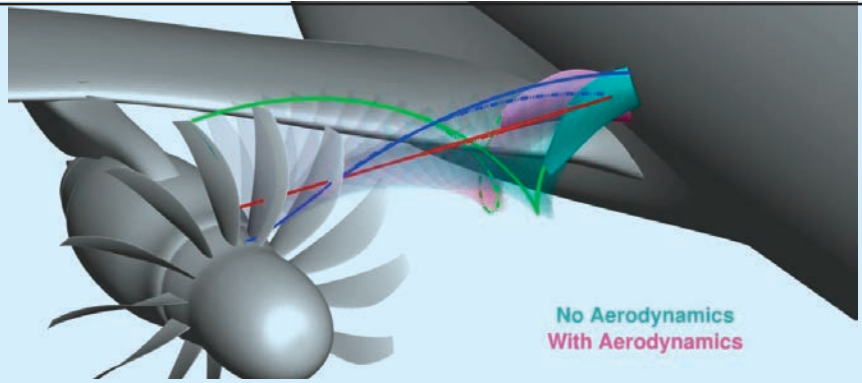
Aeroelasticity: an initial simulation of gust sensitivity control for wings with long aspect ratios.

Increasing wing span directly reduces aerodynamic drag. However, this increase wingspan means that the vehicle is very flexible, and its aeroelastic behaviour needs to be controlled.



Anticipating the risks of future aircraft with open-fans

ONERA is contributing to the safety of future open-fan aircraft by studying the problems of blade loss and fuselage armouring. Numerical simulations have made it possible to predict the possible impact zones a detached blade on the fuselage, in order identify the part of the fuselage that needs to be reinforced to make the aircraft robust. These simulations include an innovation compared with the state of the art: the inclusion of aerodynamic forces in the prediction of the trajectory of the detached



Influence of aerodynamics on the trajectory of an open fan blade in the event of detachment.

blade. At the same time, ONERA is defining armour to reinforce the structure of rocket sections and thus limit the risks associated with this type of impact. This activity is car-

ried out in the CLEOPATRA project, co-funded by the DGAC, one of whose major objectives is to study integration of open-fan engines on aircraft.

Distributed propulsion SFD test campaign: First flight a success!

On 2 May 2024, the SFD (Scaled Flight Demonstrator), a scaled-down version of a commercial transport aircraft, equipped with distributed electric propulsion (6 electric propellers distributed across front of the wing), made the first flight a test campaign aimed at mastering the new technology.

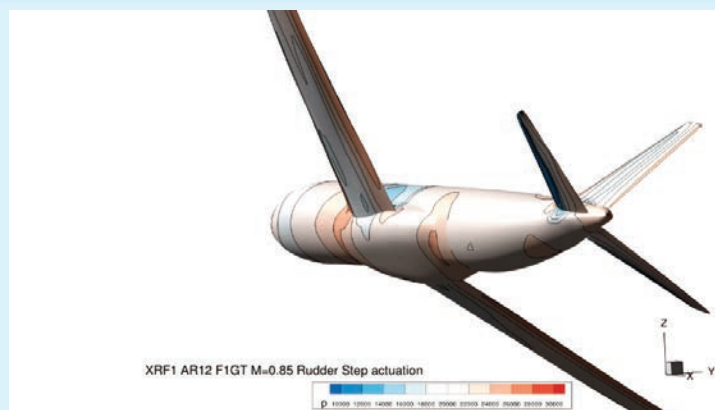
The risks inherent in this new propulsion configuration. The aim is to analyse in greater detail its dynamic behaviour in flight, in order to understand the advantages of this distributed electric propulsion technology for commercial aircraft. This SFD, developed as part of the European Clean Sky partnership, is a test bed for the study of future electric propulsion systems. breakthrough technologies. The

flight tests focused on the dynamic aspects, which made it possible to validate the predictions of the aircraft's behaviour as well as the control algorithms and the control of the aircraft by the differential wheel developed ONERA. Funded as part of CleanSky's Large Passenger Aircraft (LPA) platform, the partners in this project are ONERA, Air-us, NLR, CIRA and TU Delft with the support of Orange Aerospace



In this context, ONERA is studying gust response and has developed a digital aeroelastic simulation laboratory, based on high-fidelity CFD (Computational Fluid Dynamics) methods. As part of the DGAC MAJESTIC project conducted in cooperation with Airbus, aircraft balancing, control surface load manoeuvres and gust response calculations have been carried out.

A control law for the external ailerons was used to carry out closed-loop simulations of the response to the gust, showing a reduction in root bending moment during the gust.





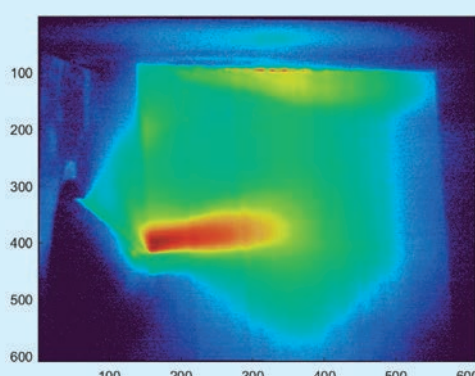
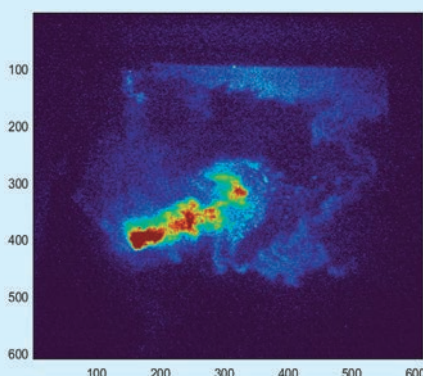
Active flow control device : Reducing aircraft drag and radar signature

A test campaign conducted in the F1 wind tunnel at ONERA's Fauga-Mauzac centre has shown that a new active flow control device on aircraft vertical stabilizer model could significantly reduce the drag of civil aircraft and the radar signature of combat aircraft. The aim is to increase the lateral force generated by the vertical stabiliser, by eliminating the lift that appears on the control surface at high steering angles. Flow control was achieved using sweeping jets, consisting of compressed air-fed jets oscillating parallel to the wall.

The tests were carried out on a generic 1/2 scale drift model.

This test campaign was carried out as part of the FACELIFT European Defense Fund project, with German SME NAVASTO as partner for the supply of the *sweeping jets*.

Aero-engines: New capabilities to characterise and improve combustion



Highly innovative tests to characterise flame/wall interactions in an aeronautical firebox were carried out using the technique of measuring induced fluorescence by laser plane applied to the OH radical. The tests demonstrated the ability of ONERA's LACOM bench to study these interactions under realistic operating conditions, in order to provide essential data improving the modelling incorporated into combustion codes.

DRONES

ONERA at the heart of the methodologies used to obtain the EASA design verification report

The European Aviation Safety Agency (EASA) has established rigorous rules for the safety of drone operations, based on a proportional risk assessment. The SORA (*Specific Operations Risk Assessment*) methodology determines the SAIL (*Specific Assurance Integrity Level*) of a drone/operation pair. Currently, operations and machines are aiming for SAIL levels III-IV, which require a DVR (*Design Verification Report*) to be obtained from EASA.

ONERA, in partnership with Aeromapper, has assisted Thales obtaining the first DVR for a complete UAV system in SAIL III conditions. This breakthrough was made possible thanks to the development a framework modelling (AltaRica) and analysing the safety of UAV systems, based on work carried out by the Reunion Convention.

DGAC PHYDIAS II research. Applied to the AVEM 300 UAV, equipped with Thales ScaleFlyt avionics and the CERBERE autopilot system developed over many years by Aeromapper in collaboration with ONERA during the first phase of the DGAC PHYDIAS I agreement, this framework is now recognised EASA. This marks a decisive step towards deployment and operation of long-endurance UAVs.

The company is operating in Europe in accordance with strict European regulations and in line with the expectations of the French Aviation Safety Directorate (DAS).
tion Civile (DSAC).



HELICOPTERS

New RACER : Outstanding contributions from ONERA

On 15 May 2024, Airbus Helicopters presented its RACER demonstrator: ultra-fast and more eco-friendly, it has benefited from ONERA's key skills in aerodynamics and aeroacoustics. ONERA has made some remarkable contributions: improving the aerodynamic shapes of the tail fins and propeller blades, improving power-plant effects, and reducing noise sources.



A test campaign in exceptional flight on the vortex phenomenon

ONERA and DGA-EV (Flight Tests) have completed a flight test campaign focusing on the vortex phenomenon, which is particularly dangerous for helicopters. This is an unstable flight condition



characterized by the aircraft entering its own wake during descent, which can lead to loss of control. The originality and importance of these unique tests lie in the variety of flight conditions investigated, the use of two instrumented aircraft (Fennec and Dauphin) and the analysis of different methods of escape from this accident-prone phenomenon.

Exit technique lateral VRS on Dauphin aircraft

MATERIALS AND STRUCTURES

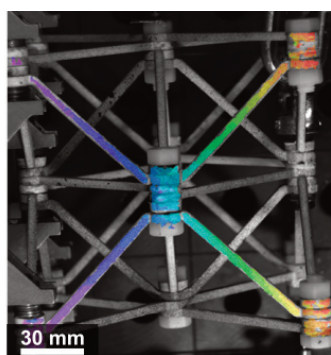
Towards ultralight architectural structures

ONERA's in-house STARAC (SStructures AR-chitecturées ACves) project is exploring the potential of architectural structures made up of repetitive elementary patterns assembled to design ultralight aeronautical structures.

This technology is of great interest because of its multi-scale integration, covering small-scale architectural materials right through to the primary structure of the aircraft.

Following a number of prototypes produced using 3D printing, an initial concept for an architectural structure was developed.

A composite was designed by ONERA. The first mechanical tests were used to study the behaviour of the periodic elemental pattern: optical cameras were used to measure the three-dimensional displacement fields. An image post-processing technique was developed to help understand the role of the assemblies. These results will be of great importance for the numerical simulation of the mechanical behaviour of these structures, which could revolutionise the design of future aircraft.



[010] displacement in the (001) plane [mm]
0.00 0.87



SPACE



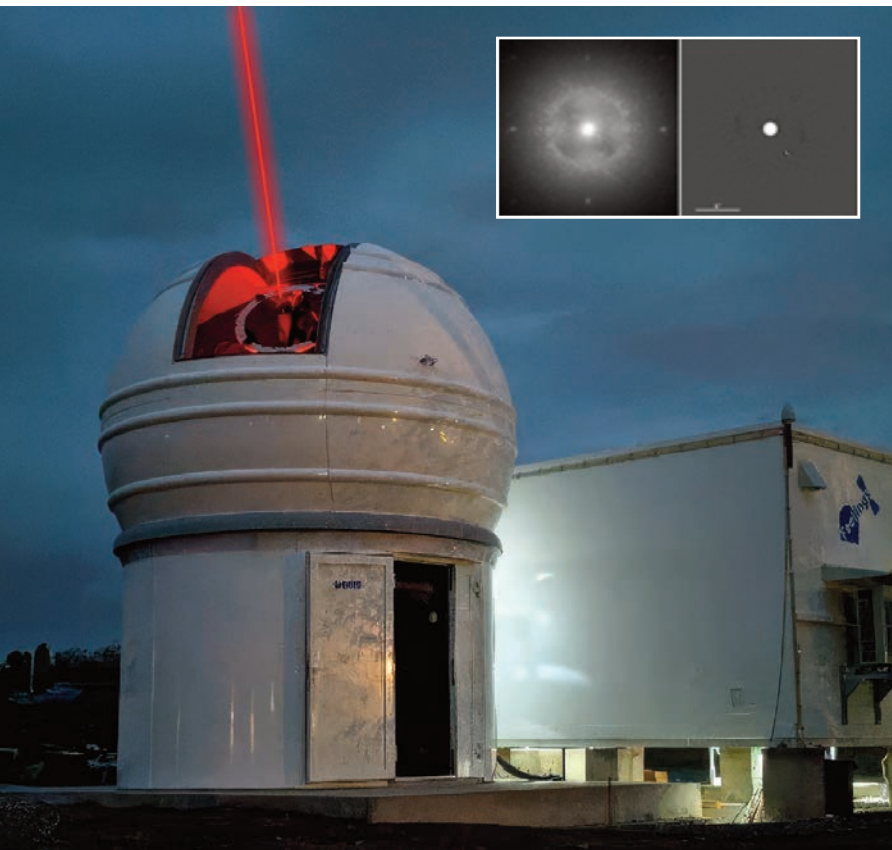
GROUND-SATELLITE LINK

Optical communications

In early 2024, ONERA took delivery of the FEELINGS ground station at its Fauga-Mauzac center. On 5 June 2024, FEELINGS established a stable, pre-compensated bidirectional laser link using adaptive optics (AO) with the TELEO payload in geostationary orbit developed by ADS (Airbus Defense and Space). This world first was made possible by AO and high-power lasers developed by ONERA. This link is compatible with very high bandwidth and opens the way to detailed studies on optical atmospheric propagation and the corrections made by AO technologies mastered by ONERA.

ONERA's participation in these demonstration activities was supported by DGA. The TELEO payload, designed to demonstrate high-speed optical links, was developed by ADS, with financial support from CNES.

FEELINGS: ONERA optical communications ground station.

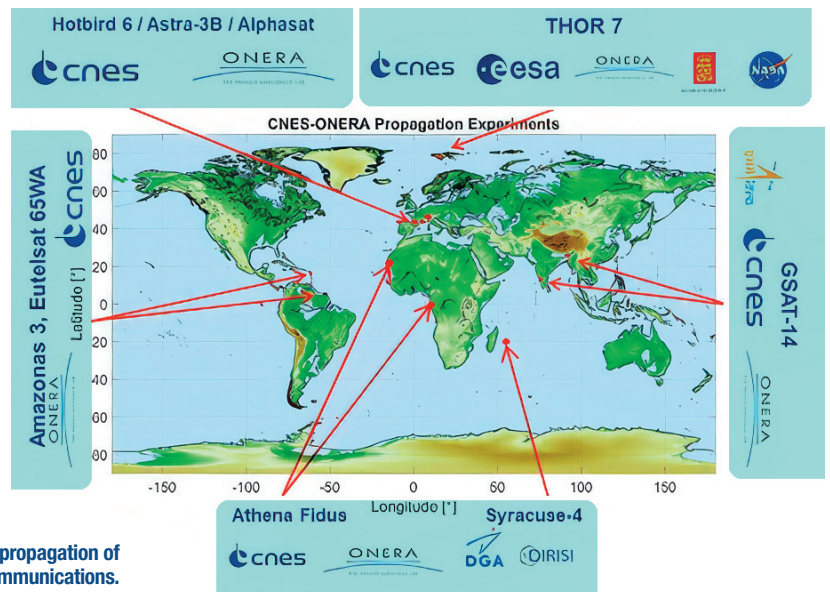


Radio frequency communications

Les travaux en propagation troposphérique radiofréquence se poursuivent avec un accent mis sur les régions tropicales et équatoriales pour lesquelles très peu de mesures sont disponibles. Les caractérisations de la propagation dans les bandes Ku/Ka sont complétés en bande Q/V.

In the field of low-frequency propagation, ONERA is continuing to develop models of ionospheric scintillation for CNES and ESA. ONERA is also continuing to forecast configurations and analyse the performance of links exploiting the trapping of waves by the ionosphere (terrestrial links) and the impact of its passage on propagation (Earth-satellite links).

Experiment to characterise the atmospheric propagation of RF waves for space telecommunications.



ACCESS AND MANOEUVRING IN SPACE

Inaugural flight of Ariane 6

ONERA successfully participated in the combined qualification tests for the Ariane 6 launcher before its maiden flight, taking part in the "short" and "long" tests on the Vulcain 2 main engine. Heat flow and temperature sensors were used to validate the operation and performance of the jet containment system (water torus, nitrogen torus and jet guide) for the launch pad (ELA4). These ONERA sensors, designed and manufactured in-house, provided accurate and robust measurements in an ultra-severe environment involving extreme temperatures, supersonic jets and very high-speed water flow.



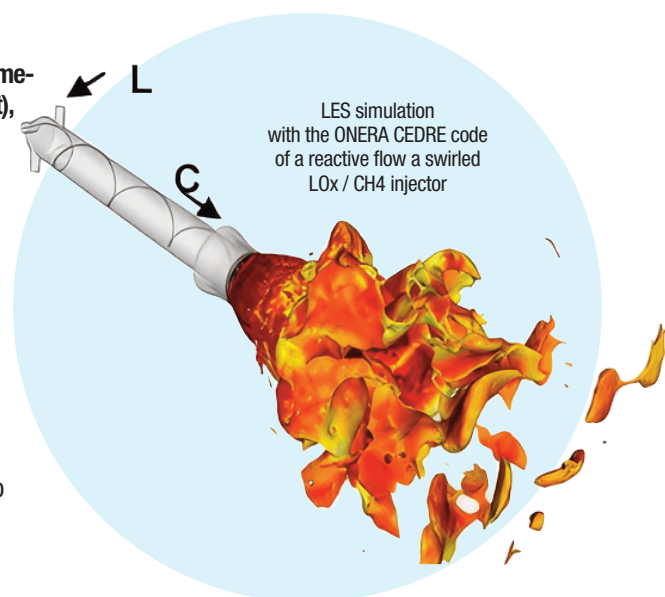
Reusable launchers

The new reusable launchers are moving towards engines using the oxygen/methane cut (for example, the PROMETHEUS engine currently under development), and technologies for returning stages and reusing them.

Through the C3PO (Cryo-technical CH₄ Plus Oxygen Combustion) programme of common interest (PIC), ONERA is continuing to validate models and carry out high-fidelity digital simulations of the combustion chamber and low-pressure gas generator.

Reuse requires the recovery of the thrust stages: ONERA is working on modelling the return of the first stage in toss back mode by modelling the interactions between the thruster jets and the supersonic flow around the stage.

ONERA is also developing innovative sensors to assess the state of health of the structures on the recovered stages in order to validate their reuse. By analysing sensor signals using AI developed as part of the European ENLIGHTEN-ED project, short-term diagnostics can be carried out, making it easier to decide whether or not to re-use the aircraft.



Propulsion in space

ONERA is developing ECRA (Electron Cyclotron Resonance Accelerator) technology with a magnetic nozzle, which could offer a competitive alternative to current solutions. The very good test results from the European MINOTOR project have been verified by performance tests in the new ERIS chamber.

ONERA and CNES have set up a PIC on use of di-iodine in electric motors, which is much cheaper than xenon, but highly oxidising, an aspect which the ECRA motor, which has no cathode, is a good candidate.

In addition, the ESA-supported IPISC (Iodine Propulsion Interaction with Satellites and Components) project, carried out in collaboration with ADS and start-up THRUSTME, aims to evaluate the interaction of iodine propulsion systems with a range of satellite materials and components, with a view to their application on intermediate-sized satellites (500 kg).

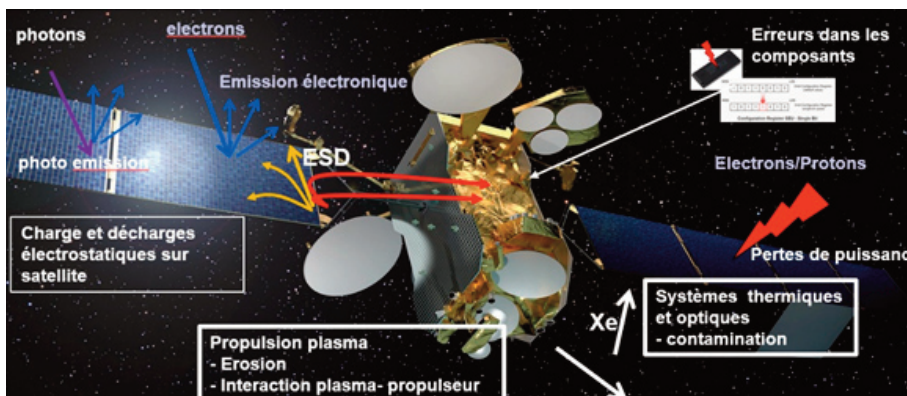


First ECRA iodine ignition.

SPACE WEATHER

ONERA, Europe's space weather leader

As part of the ESA Space Situational Awareness programme, ONERA has developed two prototype services providing users of the ESA space weather portal information and alerts dedicated to the risks associated with space missions. The aim of these prototypes is to assist satellite operators and designers in rapid analysis of potential risks, real time.



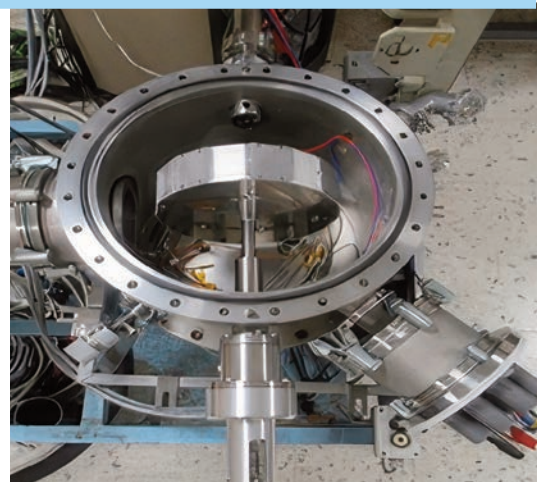
The space environment and its effects on space systems.

The first prototype alerts for the next three days, depending on the orbit considered, in relation to two major risks: degradation of the solar panels and the internal load. ONERA codes are used to reconstruct and predict the radiative environment in the orbits of interest. The second prototype, RB-IND (Radiation Belts Activity Indices) proposes a risk indicator for the effects of solar panel degradation, as well as for surface and internal loads.

Manufacturing in space and exploiting planetary resources

The ISRU (In Situ Resources Utilization) theme is driven by the prospect of man's return to the Moon and the ARTEMIS programme. The ARF's ONEMOON network, which is funded from general resources, monitors and analyses lunar exploration being carried out by international space agencies and private players, and this has helped to secure several ESA and EU contracts.

As part of the Horizon Europe DUSTER project (2022-2025), ONERA is interested in the characterisation of dust and its electrostatic transport, to counter its effects on future lunar missions or asteroids. ONERA has designed a high-precision lunar dust charge detector to study the charge acquired in a radiative environment. This detector is polarised at high voltage to attract dust and measure its charge.



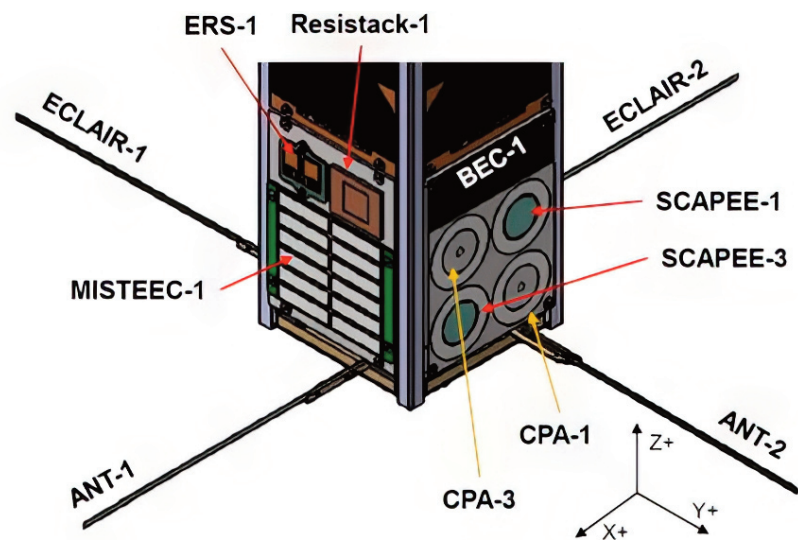
Lunar dust charge detector.

NEW SPACE

In a context of very rapid acceleration of innovation in the field of nanosatellites, ONERA is federating its activities around operational systems up to in-orbit demonstration. To meet the objectives of its roadmap 9.3 Missions and sensors for new satellites, ONERA has set up new mission concepts and innovative instruments.

The aim of the CROCUS nano-satellite is to characterise electrostatic discharge phenomena in low orbit and to test technologies for reducing them. The CROCUS design review has been completed and the launch date is scheduled for 2026.

The CREME nano-satellite qualification model was developed with ISAE-SUPAERO within the CSUT (Toulouse University Space Centre) and in partnership with several industrial partners (U-SPACE, EREMS, 3D+, TRAD). It is carrying the ONERAD miniaturised radiation monitor developed as part of CREME



↑ CROCUS nano-satellite payloads
↓ Optimisation of image capture visualised by ONERA's SpaceLab tool.

On 17 September 2024, the Inspire-SAT 7 (LATMOS) mission came to an end after 18 months in orbit. This nano-satellite, dedicated to the study of the climate, transmitted data 4 times a day to measure climatic variables using new miniaturised devices. ONERA supplied the IONO1 payload to measure the perturbations generated by the ionosphere on HF-band signals. The data collected is currently being analysed.

The preliminary definition review of the FLYLAB1 and FLYLAB2 nano-satellites (laboratories in) carrying the optical (CATFLY and CAVFLY) and radio-frequency (IONO2 and REPSAT) payloads was carried out in March 2024. The launch is scheduled for 2026.

The Horizon Europe SCARBOn project is led by ADS and follows on from the SCARBO project. The aim is to continue to increase the TRL of the Nano-Carb payload and prepare for its industrialisation. ONERA is contributing in particular to updating the airborne prototypes and the space model.

As part of the LiChE and ACCEOS projects complicated by the European Domino-E project, ONERA is continuing its integration and experimentation activities on algorithms to optimise the joint and efficient use of satellite resources, taking into account various observation , the results of which are illustrated using ONERAs SPA-CELAB tool.



SPACE MISSIONS

ONERA at the heart of large telescopes

ONERA and its partners have won an invitation to tender from the US National Science Foundation NSF) to design the adaptive optics (AO) for the Gemini Nord astronomical telescope. In November 2024, as part of an international consortium led by Macquarie University in Sydney, ONERA and its the Marseille Astrophysics Laboratory, the Haute-Provence Observatory, the SME ALPAO and the start-up Space ODT - successfully completed the preliminary design stage of laser-assisted tomographic AO system. The design will be finalised in 2025, with integration and testing due to begin in 2026. This is the new generation of AO for one of the world's largest and most powerful astronomical telescopes, GNAO (Gemini North Adaptive Optics), which will incorporate the very latest innovations in the field, making it possible to avoid the disruptive effects of atmospheric turbulence and reach its diffraction limit over almost the entire sky. ONERA has also joined a French team led by CNES, CEA and CNRS to help NASA prepare the project for the future replacement for the James Webb Space Telescope, the Habitable World Observatory (HWO).

Microscope 2 becomes STGRAAL

The Microscope 2 mission was strongly recommended by the Saint Malo scientific prospective seminar in October 2024, and will become the STGRAAL (Space Test of General Relativity and Alternative theories) project, with a phase 0 scheduled to begin in 2025.

As a reminder, the Microscope mission made it possible to test the equivalence with a precision of 10^{-15} , which not only confirmed the theory of relativity, but also made it possible to exclude parts of space from the parameters of competing theories.



ONERA at the heart of space geodesy missions

ESA has called on ONERA, world leader in space accelerometry, to supply three "new generation" accelerometers for each of the two satellites due to be launched around 2032. These new Micro STAR accelerometers, which have been in development with ESA since 2022, are expected to deliver unprecedented levels of performance and angular acceleration accuracy. This activity is being carried out in parallel with the supply of two accelerometers to the JPL (Jet Propulsion Laboratory) and NASA for the future GRACE-C mission, which will be launched at the end of 2028. NGGM and GRACE-C will form the MAGIC constellation of four satellites, dedicated to mapping the Earth's gravity field and its changes with unprecedented precision. ONERA is also involved in the EU CARIOQA project and the Pathfinder Mission Program activity, PMP CARIOQA, whose objective is identify the performance of an accelerometer hybridising the electrostatic technology used on the geodesy missions mentioned, and quantum accelerometer technology that will be used on the MAGIC satellites. will be used for the CARIOQA mission.

ONERA MicroSTAR accelerometer for the ESA NGGM mission

GEMINI North telescope, Mauna Kea, Hawaii.



ONERA'S LARGE WIND TUNNELS

S1NMA

SERVING
INNOVATION IN
AERONAUTICS
AND DEFENSE

S2MA

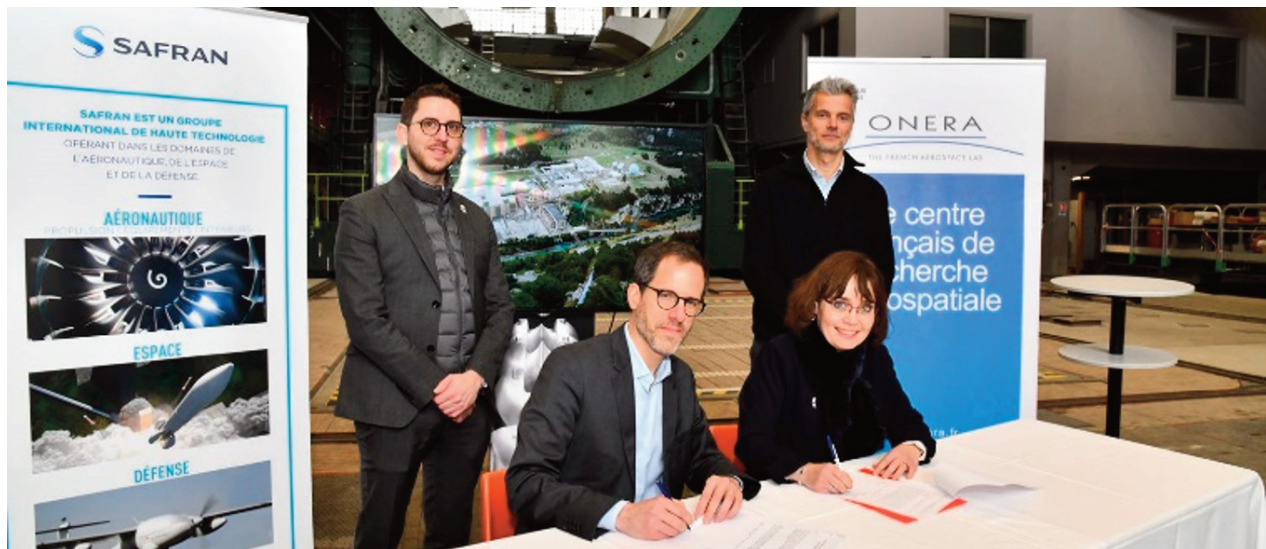
F1

2024 - A new record for order intake, test activities that are set for the long term

The year 2024 ended with a new order intake record for Wind Tunnels Division, far exceeding the already exceptional figure for 2023: more than €58m in orders were booked, from both French and foreign customers, reaffirming their confidence in the quality of the services provided. This confidence reflected, among other things, in the signature of a framework contract with SAFRAN. This exceptional contract marks a multi-year commitment to work on new engines for low-carbon aircraft, and provides visibility on the wind tunnels' workload plan.

More than half of the 2024 test activity in the major wind tunnels was devoted to civil tests, in particular EcoENGINE tests - as part of SAFRAN's RISE programme (OpenFAN type engine) - in isolated configuration or installed in S1MA. Defense work for fighter aircraft or conventional or strategic missiles accounted for 35% of activity, mainly on the S2MA wind tunnels (Mach 0.1 to 3) and the gust wind tunnels (super and hypersonic).

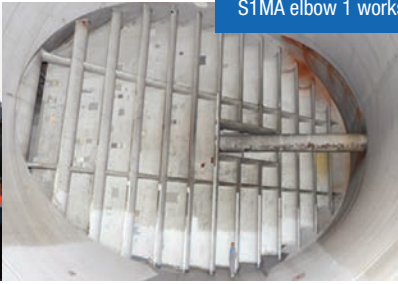
SAFRAN AE and the wind tunnel management team sign a framework agreement.



he DGAC confirms its support for the development an ultra-miniaturised acquisition system: SCAMPIS

In 2022, the DGAC notified a subsidy contract to finance the work on the SCAMPIS project (Système Chaîne d'Acquisition de Mesure de Pression Instationnaire en Soufflerie) developed by the Wind Tunnels Division and designed to replace 'cumbersome' pressure measurement equipment on models with miniaturised systems. Equipped with high-performance electronics close to the measurement point, such systems will be able to achieve unrivalled measurement performance, particularly in terms of . At the end of the first phase of work, aimed at reaching technological maturity level 4 (TRL 4), with laboratory tests, the DGAC confirmed the 2(th) conditional tranche enabling the launch of phase 2 work, including tests under real conditions at S1MA.

A number of emblematic milestones in the ATP project were completed in 2024



S1MA elbow 1 worksite - delivery of blades (April) - dismantling (July-August) - reassembly (October 2024).

As the ATP programme to maintain and modernise the major wind tunnels draws to a close (scheduled for 2026), a number of symbolic milestones have been reached in 2024. Over the summer, a number of projects were carried out at Modane that had no impact on test activity. Renovation of a 90° bend in the S1MA was completed, reducing the maintenance load on ageing blades that required regular inspection and repair. This project will be completed a second phase involving the installation of acoustic enclosures that will improve the acoustic performance of S1MA by reducing the background noise in the wind tunnel.

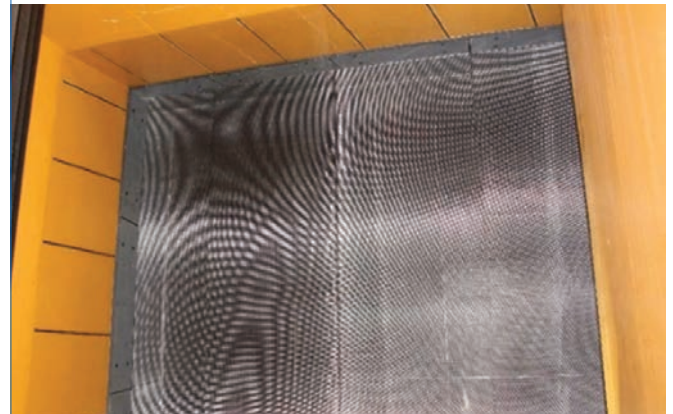


Installation of BP compressors at Fauga Mauzac



S1MA diffuser painted summer 2024.

At the same time, the high-voltage cells at Modane were replaced and painting of the S1MA circuit was completed. Finally, the installation a ball valve for S1MA, replacing the old 27-tonne valve that had leaked in 2021 (and led to a wind tunnel im- mobilisation of S1MA) was completed and the C11 compressor, enabling the extension of Modane's compressed air capacities, was installed.



New tranquillisation chamber at Le Fauga Mauzac.

At Fauga Mauzac, the installation of new BP3 and BP4 compressors will enable the company to upgrade its compressed air production capacity. A new plenum chamber has installed in the F2 wind tunnel.

The Wind Tunnels Department is showcasing its test data as part of international cooperations and on the national research data platform

For several years now, the Wind Tunnels Department has been developing a series of reference models known as Large Reference Models (LRMs). The high-lift version, known as LRM-HL - *large reference model high-lift*, was designed and manufactured in our Lille workshops, then tested in the F1 wind tunnel at Fauga-Mauzac in 2022 and 2023. The results were widely publicised in August 2024 at *the 5th High-Lift Prediction Workshop*, which together dozens of international academic and industrial bodies. ONERA was the only organisation able to deliver usable experimental results, providing a unique validation basis for the hundreds of simulations presented at the workshop. Highlighted on the national research data platform *Recherche Data Gov*, this database was then widely downloaded, confirming the interest of research players in the data produced in a large industrial wind tunnel

Press visit to Modane to discuss SAFRAN AE's RISE project

On 19 January, SAFRAN AE organised a press visit to the S1MA wind tunnel in Modane to coincide with the testing of the OpenFAN technology development programme. This event highlighted the importance of a wind tunnel like S1MA (and above all, the importance of having saved it) in supporting innovations for low-carbon aviation, particularly in terms of new types of engines and drive systems. During the event, SAFRAN AE through Eric Dalbiès, R&T Director at Safran and ONERA Director, and Pierre Cottencaeu, Technical and R&T Director at SAFRAN AE, underlined the importance of these facilities and the expertise of ONERA's teams.



ONERA inaugurates the new large wind tunnel model workshop in Lille

On October 1, 2024, ONERA inaugurated its new model workshop in centre of Lille, in the presence of Xavier Bertrand, President of the Hauts-de-France Region, Bruno Sainjon, Chairman and CEO of ONERA, and the press.

This project marks the conclusion of the transfer of model-making activities from Meudon to the Lille site, a major milestone in the ATP programme and the PRISME site reorganisation project. This involved building an extension and reorganising the existing workshop in Lille to accommodate the teams and machines. One of the challenges of this transfer activity was to maintain skills in the field of balances, cutting-edge metrological equipment essential for ensuring the quality of wind tunnel measurements. Thanks to the recruitment and investments made, the wind tunnel management has succeeded

in retaining this unique skill. As part of this extension, numerous investments were made to boost productivity, maintain production quality at the highest level, and meet the growing and new needs of the

wind tunnels in terms of scale and model production. Part of this investment should be supported by the region through the European Regional Development Fund (ERDF).



DIGITAL SIMULATION

ONERA DIGITAL SIMULATION STRATEGY

En route to ORION

ONERA presented its strategy for the future of digital simulation at the ONERA 2024 Scientific Days "Multi-physics Simulation Environments and Platforms" in front of its supervisory body and its main industrial and academic partners. These days were also an opportunity to compare its ideas with those of experts a wide range of backgrounds, including the Institut Jean-le-Rond d'Alembert, the École polytechnique, Coria, IFPEN, Safran and Google DeepMind.

The strategy presented is based on the following main points:

- Launch a new generation of simulation software ready exascale, GPUs and AI;
- Base this software on common building blocks shared within an environment called ORION;

- Leading software towards multiphysics calculations at frontiers.

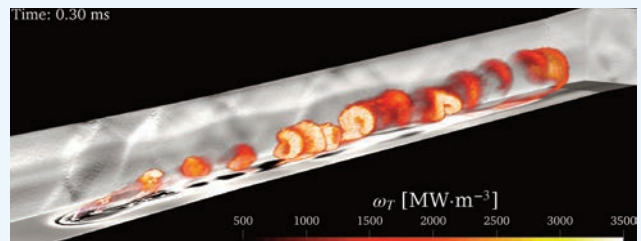
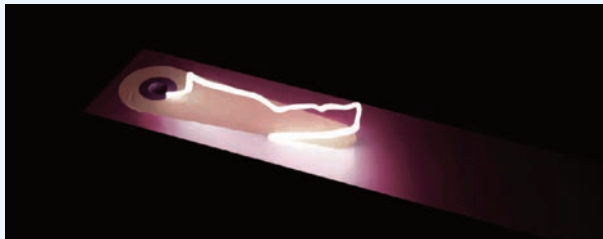
Simulation software such as elsA or SoNICS for aerodynamics, developed in partnership between Safran and ONERA, and CEDRE via pyCEDRE for energetics are already based on this common ORION environment. The CODA software, developed in partnership between Airbus, DLR and ONERA, and its FSDM software environment can also be interfaced with ORION. Our researchers are also involved at several levels in the development of the ProLB software for simulation using the Lattice Boltzmann method, in partnership with the Labs consortium.

ONERA's aim is extend the ORION approach to several other professions and physical areas of interest to the aerospace and defense sector.

Impactful multiphysics numerical simulations

Some systems cannot be designed precisely by taking into account a single discipline. Several physics disciplines need to be combined. ONERA engineers have studied the ignition of flames by an electric arc in a combustion chamber in the presence a high-speed flow. To do this, the TARANIS software, which models magnetohydrodynamics, was coupled to the CEDRE software, which simulates combustion. Through this type of work, ONERA is making progress in understanding the effect of electric arcs on flame stability.

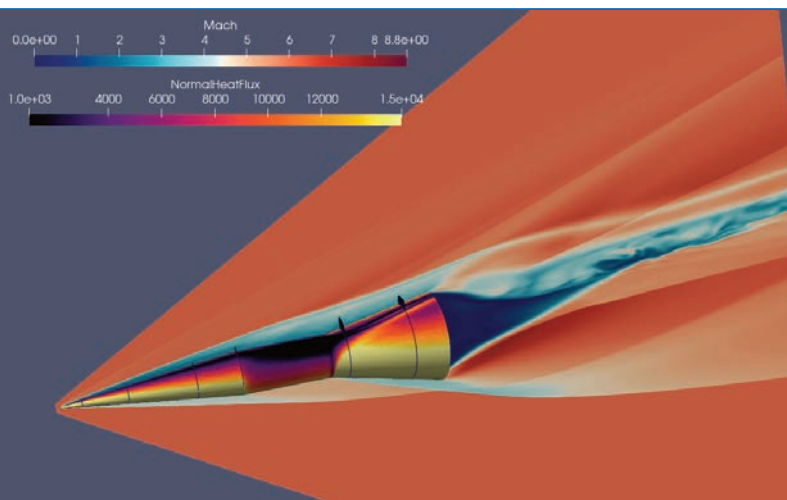
Simulation of an electric arc using Taranis (left); coupled Taranis (MHD)-CEDRE (combustion) simulation of arc of flames in a combustion chamber (right).



Mesh adaptation to assist design

Mesh adaptation is increasingly used in design processes, either to reduce mesh generation time or to reduce the uncertainty of the results obtained. For example, it has been used

in the design of a flight demonstrator to study aerodynamic behaviour in the hypersonic regime. As part of a FREHyA academic research project, in collaboration with CEA CESTA, the SoNICS solver is being used to design a flight object with a simple shape that optimises the phenomena. This marriage makes it possible to obtain aerodynamic fields and to analyse finely the boundary layers the flow, making it possible, for example, to estimate the frequencies of the instabilities responsible for the transition towards turbulence. The simulation chain has also it possible to generate a database of calculations, from which an aerodynamic model of the craft can be established to calculate and disperse trajectories.



Hypersonic configuration at incidence. Heat flux on the object and Mach number in cross-section.

GPUs and AI for digital simulation

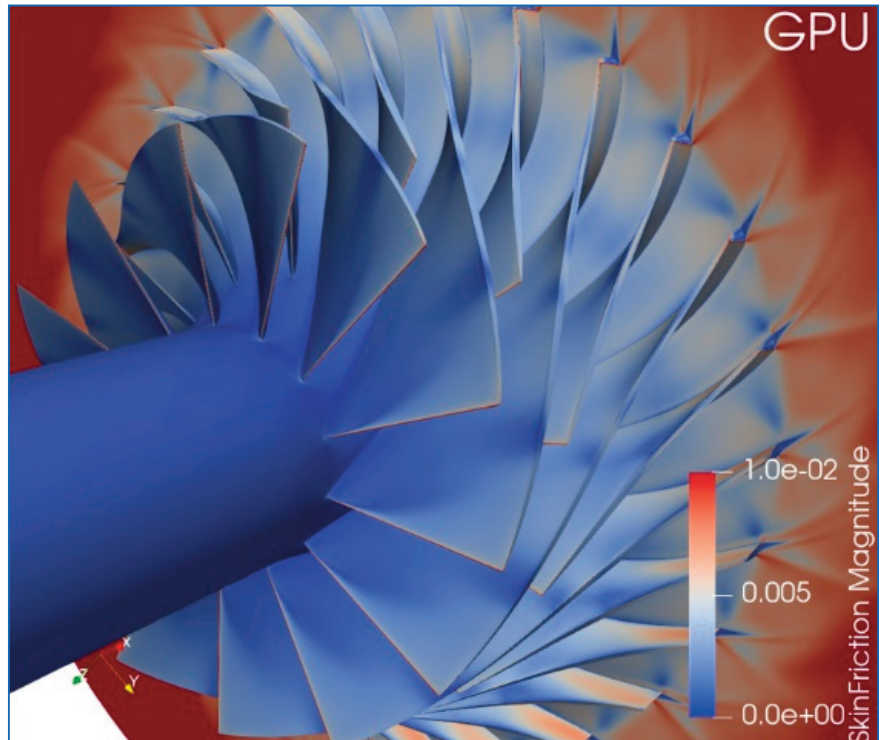
We are entering the era of exaflop computing, with power levels in excess of one billion billion operations per second, which will be achieved on future large-scale European computers. This computing power will be provided mainly by GPU (Graphics Processing Units) chips.

To prepare for the future, ONERA is working on transferring its software algorithms to GPUs and is launching a new generation of simulation software that is particularly optimised for this type of processor. For example, the SoNICS software, which is designed to take advantage of hybrid architectures (CPU, GPU, NEC VE), has already carried out several demonstrations on GPUs.

Similarly, the new-generation CODA software, designed to meet Airbus's aerodynamic simulation needs, has also made the move to GPU computing.

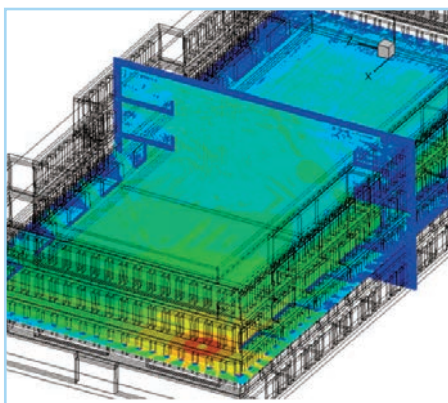
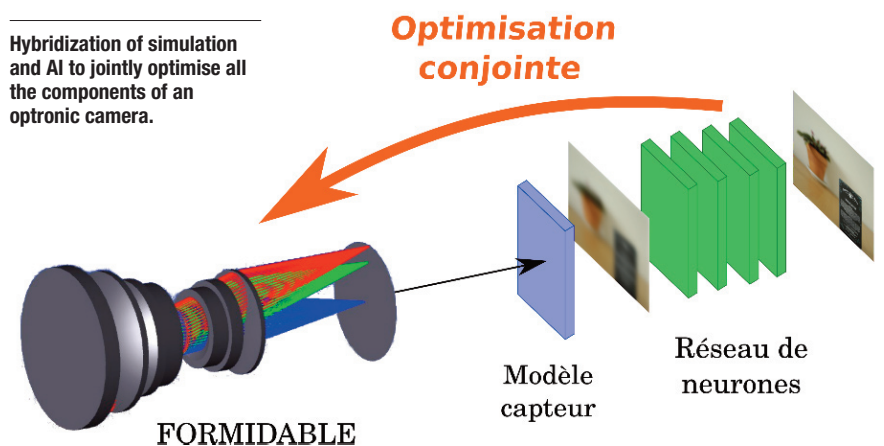
In addition to numerical simulation, the growth of GPU computing is greatly fuelled by advances in AI. ONERA is developing self-learning within its AILab laboratory and deploying them within its scientific departments.

A great deal of work is being done, in particular, to combine digital simulation and AI. For example, ONERA has developed an AI-assisted simulation approach for an electromagnetic attack scenario on a building for the 2024 Olympic Games. In this case, the parametric aspect of the simulation is used to feed the AI to improve the detection and characterisation of the attacking electromagnetic source.



GPU calculation of the SRV2 centrifugal compressor using the new-generation SoNICS software.

Researchers at ONERA have also used this type of approach to co-design optics, sensor and image processing for the FORMIDABLE optronic camera system. To do this, they hybridised the differentiable simulation of an optical system and the sensor with a neural network for image processing, and thus jointly optimised all the elements of the system.

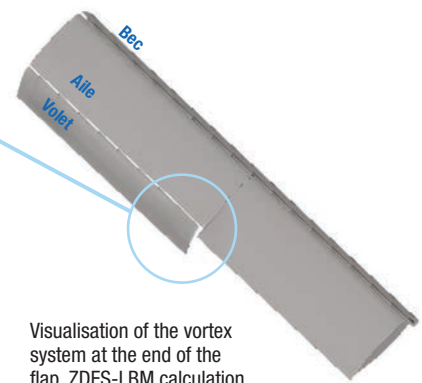
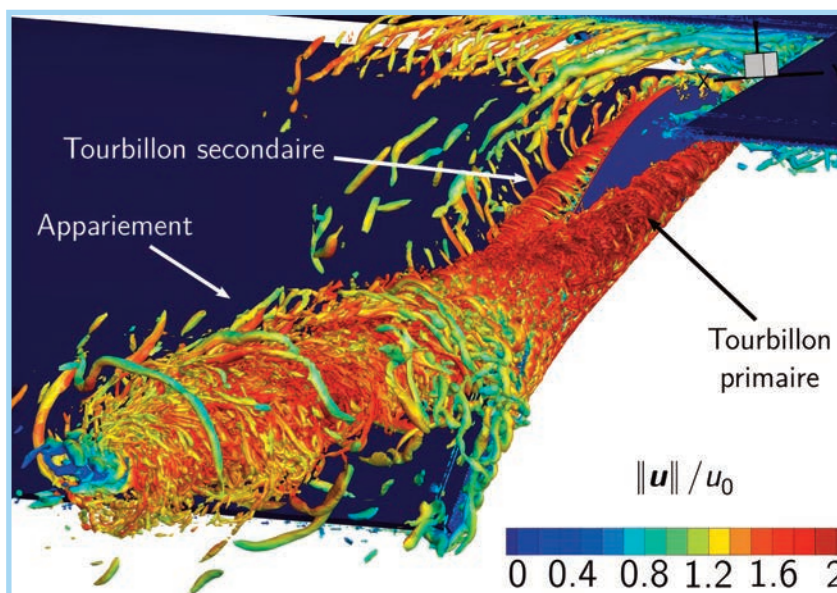


← AI-assisted simulation electromagnetic attack scenarios on a 2024 Olympic Games building.

SIMULATIONS TO SUPPORT OUR INDUSTRIAL PARTNERS

Efficient coupling between approaches to better simulate turbulence

ONERA is increasingly developing the ProLB software to support Airbus and Safran in their industrial projects. A major bottleneck in the use of the Lattice Boltzmann method for aeroacoustic applications has been overcome thanks to a coupling with ZDES (Zonal Detached Eddy Simulation) of turbulent boundary layers applied to the numerical simulation of flap tip noise. This coupling also significantly reduces computing costs. The simulation of the flow along a flap tip was made possible with just 120 million nodes compared with more than 4 billion using conventional approaches. This has made it possible to locate and quantify the sources of noise.

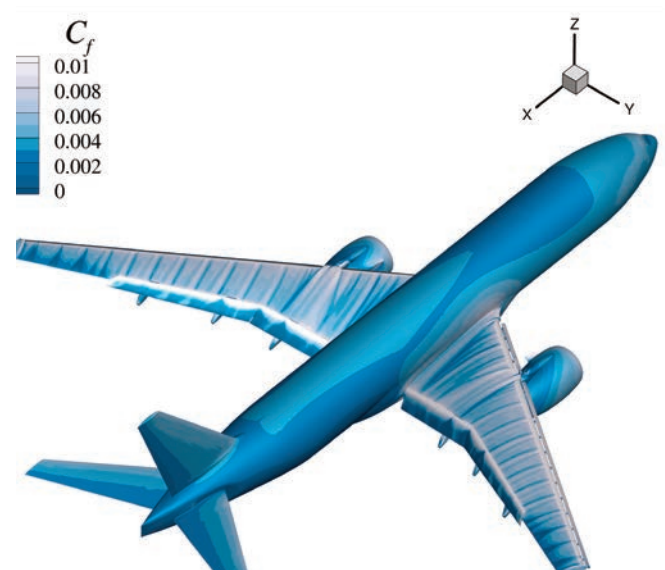
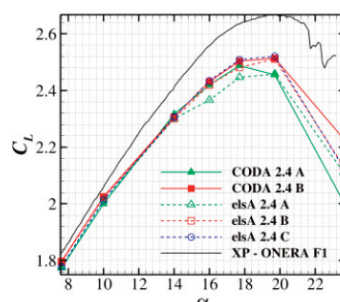


Visualisation of the vortex system at the end of the flap. ZDES-LBM calculation using ProLB software.

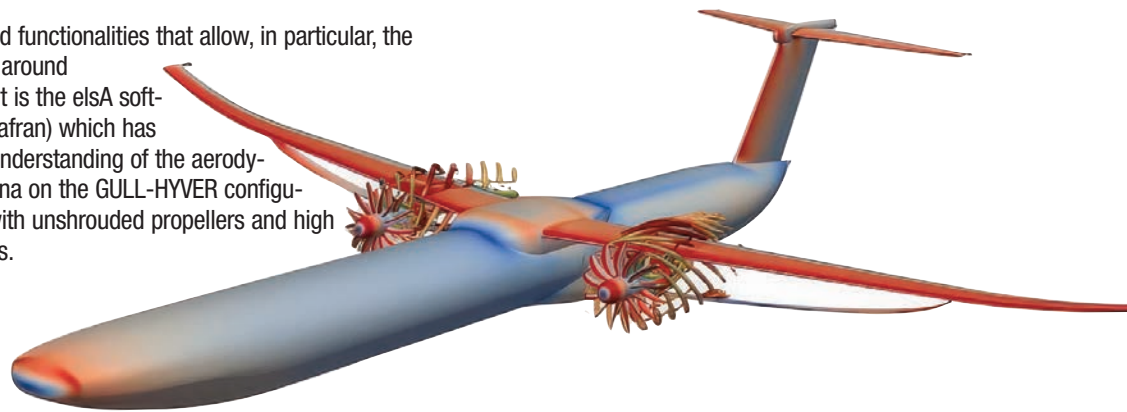
Full aircraft simulations

Several simulations of a complete aircraft were carried out in 2024 using different ONERA codes as part of the "Aircraft of the Future" challenge in the "Aerospace digital simulation application challenges" roadmap. Comparisons between calculations and tests presented at the 'High Lift Prediction Workshop' demonstrated the ability of the CODA software (ONERA-DLR-Airbus) to produce simulations representative of the physics in this flight regime.

CODA calculation of a High-Lift Prediction Workshop configuration.



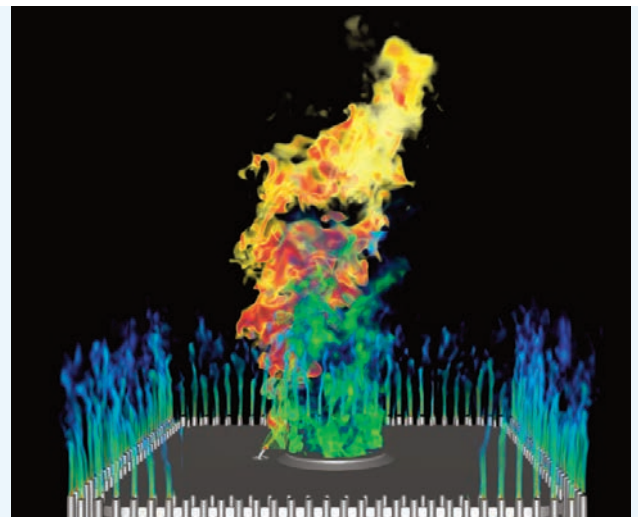
It is equipped with advanced functionalities that allow, in particular, the unstable simulation of flow around of fixed and rotating parts, it is the elsA software (property of ONERA-Safran) which has been used to gain a better understanding of the aerodynamic interaction phenomena on the GULL-HYVER configuration containing engines with unshrouded propellers and high aspect ratio shrouded wings.



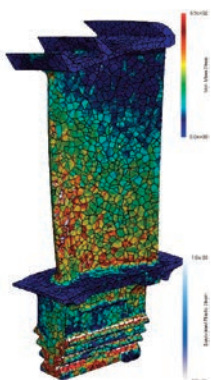
elsA unsteady calculation of the Gullhyver configuration with a non-split engine.

On the aerospace side: Low-NOx injector design using the CEDRE code

Hydrogen combustion is being studied as a solution for decarbonising air transport. ONERA has been working on the design of hydrogen-powered injectors for several years. As part of the DGAC HYPERION project, ONERA has designed a stable, ultra-low-NOx H₂/air injector (called IHI) using the CEDRE code, based on the use of a lean pre-mix. After testing 80 configurations, the concept was validated by tests on the MICADO bench and an ONERA-Safran patent was filed. Subsequently, the H2TECH project, which is still in progress, enabled ONERA to improve the IHI injector by adopting the same strategy, the aim of reducing pressure losses, reducing the number of injection systems to 1 per injector, compared with 4 on the IHI, and extending the operating points. No fewer than 25 configurations were tested using simulation, with variations in the type and position of the swirler. Tests on the MICADO test bench will start in spring 2025.



Temperatures from yellow to red; H₂ mass fraction from blue to green and then to yellow at the injector outlet; Axial velocity at the periphery of the cooling films.



High-fidelity simulation of polycrystalline blades with Z-set

Recent advances at ONERA in high-performance computing mesh adaptation have made it possible to model polycrystalline blades, taking into account the microstructure of the part. A microstructure made up of 7357 grains is inserted into blade mesh and each grain follows a highly non-linear crystalline plasticity behaviour in large deformation. The blade is subjected to thermomechanical loading combining centrifugal force and thermal deformation produced by the gas flow. The simulation was carried out using Z-set. Using 100 cores, it was completed in less than 10 hours. These high-fidelity simulations, carried out in collaboration with Safran Tech, it is possible to estimate the influence of microstructure, and in particular grain boundaries, on mechanical parameters such as stress and plasticity.

VALORIZATION

While aeronautics, space and defense research is ONERA's primary mission, transferring the results of this research to industry is a major national challenge. ONERA's mission is to promote its expertise and accelerate innovative projects. This is the mission of the Development and Intellectual Property Department (DVPI).



ONERA ACADEMY®

ONERA is conducting its first professional training course dedicated to atmospheric simulation.



A professional training course on MATISSE software tool was held from 19 to 20 March 2024. This first training course, aimed at external customers, marks an important step for ONERA, which plans extend its range of specialist training courses under the name "ONERA Academy".

This 2-day course, led by research engineers from the Optics and Associated Techniques department, enabled trainees to master the various models in the MATISSE code and optimise their expertise in simulation projects.

The learners were very satisfied with the course, as their feedback shows:

- "Training that goes beyond simply using MATISSE. The progress is excellent and the trainers are always ready to listen and available to help."

- "The software interface is very intuitive, making it easy to learn the code. Very good balance between theory and practice during the course. Very good availability of trainers to answer questions and solve problems."

- "Very satisfied with the training, effective and optimal in relation to my objectives, even if I will probably only use some of the tools presented."

What is the MATISSE code?

MATISSE is an Advanced Earth Modeling code for the Imaging and Simulation of Scenes and their Environment. This training course for version 3.6, approved by the French Defense Procurement Agency (DGA), aims to speed up simulation developments in terms of propagation and atmospheric radiative transfer in the learners' optical domain.

INTELLECTUAL PROPERTY INDICATORS 2024

12 new patent applications

9 new invention declarations

34 new software registered

93 licence agreements in progress

12 new Soleau envelopes

20 new licences

ONERA DROSERA

DROSERA[©]

A mission preparation tool for the drone industry, to automatically assess and control the level of risk on the ground.

Before flying a drone of a specific category under European regulations, you need to carry out a risk assessment using the SORA (Specific Operations Risk Assessment) method. For the drone operator, this means spending a lot of time providing circumscribed and convincing data to the authorities when applying for a flight permit.

In response to this situation

DROSERA[©], originally a collaborative research project between ONERA, Rte and Altametris, has evolved into an operational tool for the drone industry.

DROSERA[©], released by ONERA in April 2024, offers a number of functions, including:

- Calculation of overflight population densities and risk classes, values and distribution over the risk footprint and

adjacent area, for the whole of France;

- Identification of roads, railroads and power lines overflight and classification according to importance (e.g. free-way);

- Automatic generation a summary sheet with assessment results;

- Mapping to locate and visualise risks.

ONERA is listening carefully to the players in the drone industry and the aviation safety authorities, and is continuing to develop new functions to enhance DROSERA[©]. A new version will be available in 2025.

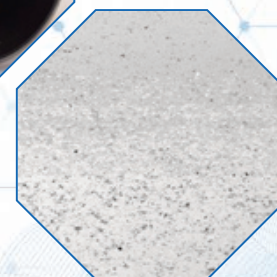
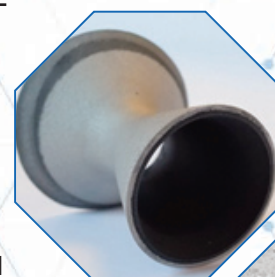
EXTREM-FGM[©]

AN INNOVATION FOR THE PROPULSION OF THE FUTURE

ONERA, in collaboration with CNES and UTBM, has developed EXTREM-FGM[©], an innovative material designed for engines using new propellants that are less toxic and more energetic than hydrazine. This gradient material offers exceptional resistance to extreme conditions, withstanding temperatures in excess of 1600°C, even in the presence oxidising species.

Unlike traditional Rhenium/Iridium combustion chambers, which are costly and temperature-limited, EXTREM-FGM[©] stands out for its optimised design: less than 2 mm thick compatible with various structural materials and low manufacturing cost. Its performance has been validated through representative tests, totalling 50 thermal cycles over durations of up to 300 seconds, confirming a TRL 3 rating.

Currently supported by ONERA's DVPI, this material benefits from support to increase its TRL and explore new industrial applications, in particular via a POCinLabs project with the University of Paris-Saclay. Two innovations are already under way to pursue these technological advances and position EXTREM-FGM[©] as a key solution for tomorrow's space propulsion.



INTERNATIONAL

UNITED STATES

Cooperation with the US Army: New ambitions

The US Army Combat Capabilities Development Command (DEVCOM) and ONERA have been cooperating for more than 50 years in the field of helicopters via the AHFIR (Rotary Wing Aeromechanics and Human Factor Integration Research) cooperation agreement. This successful cooperation also includes the regular visits and hosting of American military personnel who take part in ONERA's research activities.

In addition, on 14 February 2024, ONERA received Colonel Seaberry, Director of DEVCOM Atlantic, which is notably responsible in particular for cooperation with Europe. Discussions focused on ongoing cooperation, research to be initiated to meet the future technological and capability needs of our armed forces, and the opportunities for ONERA personnel to work in American military laboratories as part of the Engineer and Scientist Exchange Program (ESEP).



From left to right: R. Mathurin (DTP), O. Vasseur (DAI), C. Seaberry (US Army), E. Quiraitte (US Army), P. Sparks (US Army), L. Leylekian (DAI)

SAUDI ARABIA

Discovering of ONERA's activities

On 15 February 2024, ONERA welcomed a delegation from Saudi Arabia to its Palaiseau centre. The delegation was led by Dr. Faleh bin Abdullah Al-Sulaiman, Governor of the GADD (General Authority for Defense Development), which is responsible for defense R&D planning in the Kingdom. The delegation included 14 Saudi officials, including General Adel Awad Alotaibi.

The objective was to discuss potential avenues for cooperation. The delegation was accompanied by the French Defense Innovation Agency represented by Laurent Vieste, and DGA's International Division.



LITHUANIA

Defense innovation : Visit a Lithuanian delegation

On 11 September 2024, at the request of AID, ONERA welcomed a Lithuanian delegation at its Palaiseau as part of an experience-sharing initiative in the field of innovation for defense. The delegation was made up of representatives from the Lithuanian Embassy in Paris and specialists from the Ministry of the Economy and the Lithuanian Innovation Agency for Defense.



From left to right: P. Petrauskas (Innovation Agency Lithuania), S. Stankevičiūtė (Innovation Agency Lithuania), E. Griškās (Ministry of Economy and Innovation), J. Dubreuil (AID), D. Kirkilaitė-Chetcuti (Lithuanian Embassy in France), M. Survilas (Innovation Agency Lithuania), R. Martinavičius (Ministry of Economy and Innovation), O.Vasseur (DAI), L. Ruiz (DTP).

SINGAPORE

ONERA and the DSO extend their cooperation to new themes

The 9th Advisory Board meeting on cooperation between DSO and ONERA was held on Thursday 4 April 2024 at CentraleSupélec. Two cooperation agreements were signed in 2024, extending cooperation to cover virtually all ONERA's fields.

Celebrating 20 years of the SONDRRA research laboratory

As an evidence to the continued commitment to cooperation, a ceremony was held on 4 April 2024 in the presence of Emmanuel Chiva, Délégué Général de l'Armement, Melvyn Ong, Singapore's Permanent Secretary (Defense Development), and Cheong Chee Hoo, CEO of DSO National Laboratories, Bruno Sainjon, CEO of ONERA, Romain Soubeyran, Director of CentraleSupélec, Heng Chye Kiang, Deputy Dean (Research & Innovation), College of Design and Engineering, National University of Singapore (NUS), and of course the founders of the laboratory: Chan Hian Lim and Marc Lesturgie (Electromagnetism and Radar Department when SONDRRA was created, now Director of International Affairs).

Supported by a quadripartite alliance, SONDRRA conducts innovative studies in the field of radar and associated processing. Backed by a strong support from the French and Singaporean governments, SONDRRA remains unique in France and benefits from substantial resources to enable its scientific teams to carry out academic research in physics (propagation, bottom signatures), signal processing, electromagnetism and data (AI for example) applicable to radar and remote sensing.

In 20 years, SONDRRA has acquired international stature. For ONERA, Singapore is the leading bilateral cooperation partner outside the EU (the only integrated team cooperation) on dual-



Stéphane Saillant, ONERA/DEMR and Director of SONDRRA; Cheong Chee Hoo, CEO of DSO National Laboratories; Bruno Sainjon, Chairman and CEO of ONERA; Emmanuel Chiva, Director General for Armaments; Melvyn Ong, Permanent Secretary (Defence Development) of Singapore; Romain Soubeyran, Director of CentraleSupélec; Heng Chye Kiang, Deputy Dean (Research & Innovation), College of Design and Engineering, National University of Singapore (NUS).

use civil/defense topics. This strong relationship has contributed to the entry of a Singaporean institution into the IFAR network (International Forum for Aviation Research), of which ONERA has held the presidency since 2023. Cooperation with Singapore is also supported through technical arrangements managed by the French Ministry of the Armed Forces' Defense Innovation Agency.

IFAR 2024 International Summit: ONERA asserts its leadership role at the heart of multilateral cooperation projects



The 15th IFAR Summit (International Forum for Aviation Research) was held from 23 to 26 October 2024 in Singapore, for the first time under the French Presidency. 18 nations were represented, including the American NASA, the Dutch NLR, the Canadian NRC, the German DLR and the Japanese JAXA, hosted by the Singaporean A*STAR (Agency for Science, Technology and Research), which joined IFAR in 2022.

ONERA has asserted its position by coordinating the ELECTRIFLY research project (ONERA, NRC, JAXA, NLR, NASA, DLR cooperation). ELECTRI-FLY (atmospheric ELECTricity Characterization ThRough In-Flight) aims to characterize the electrification process of an aircraft passing through a real atmosphere, an important characterization in view of the use (and certification) of new structures and composite materials. ONERA has also been designated co-leader, with the Canadian NRC, of a project to accelerate certification through "digitisation", in close collaboration with the ICAO (International Civil Aviation Organisation): the partnership between IFAR and the ICAO, the subject of an agreement signed in 2022, is starting a second phase of work on this subject, confirming the mutual interest of the two international organisations.

The PULSAR project led by ONERA at the European Parliament

PULSAR (Propelling eUropean Leadership through Synergizing Aviation Research) aims to accelerate the transition to a more sustainable aviation by developing a European roadmap for research and innovation in the field of aeronautical noise and emissions. On 9 April 2024, a round table was organised at the European Parliament by the PULSAR consortium to present recommendations: what are the research priorities for the European aeronautical sector to best meet the EU's environmental objectives?

ONERA presented the approach of the PULSAR project that it is coordinating, based on four hypotheses of socio-economic scenarios, the associated air traffic profiles, and a quantitative and qualitative assessment of the impact of different technologies on these scenarios. The technologies considered are aircraft noise reduction and emissions reduction or carbon offsetting through the use of sustainable or synthetic fuels.



Marco Grancagnolo, Benoît Chaucheprat, Catherine Bender, Nynke Tigchelaar, Laurent Leyeikian, Jean Leger, Christophe Gomart (MEP), André Loeseckrug-Pietri

EU competitiveness and defense: ONERA creates a stir in Brussels

On Tuesday 10 September, the conference entitled “Optimising the European Union's R&D strategies on dual-use technologies to meet the challenges of competitiveness and Europe's military challenges” enjoyed great success. Held at the French Permanent Representation to the EU, it brought together over 150 attendees - members of the Permanent Representations, European Commission staff, representatives from the European research and industry, as well as Christophe Gomart, MEP and Vice-Chairman of the European Parliament's Defense and Security Sub-Committee - to discuss a subject that is crucial to the European Union's strategic autonomy.

ICAS 2024: ONERA and IFAR take part with flying colours

At the ICAS (International Council of Aerospace Science) conference held from 9 to 13 September, Bruno Sainjon, in his capacity as IFAR Chairman, signed the renewal of the partnership between the two organisations with Dimitri Mavris (Georgia Institute of Technology, USA). The agreement aims to facilitate exchanges and cross-participation in events organised by the two organisations. The partnership also includes a joint scientific prize, which this year was awarded to DLR.

At an ICAS plenary session, Bruno Sainjon chaired the IFAR session on “Air Traffic Management as a key for sustainable aviation”, during which ONERA, CIRA, NASA, DLR, NLR and A*STAR presented their respective advances.



Scientific recognition

EREA, the association of European Research Establishments in Aeronautics, has awarded its prize for best publication in 2024 to ONERA. This is the 11th time in 15 editions that ONERA has received this prestigious award, a testament of the very high scientific level of its research engineers and their dynamism in terms of publications.



From left to right: Bruno Sainjon, Chairman and CEO of ONERA; Anke Kaysser-Pyzalla, Chair of the DLR Executive Board; Markus Fischer, Member of the Executive Board in charge of Aeronautics, DLR.

ONERA and DLR sign renewal agreement of their cooperation

At ILA 2024, the two organisations signed a new MoU (memorandum of understanding) to formalise their commitment to cooperate on a wide range of subjects, including helicopters, AI applied aeronautics, decarbonisation, metrology, propulsion and aircraft vibrations. The agreement signed follows 25 years of cooperation, which began in the late 90s with Eurocopter, now Airbus Helicopters. The two organisations then began organising joint conferences, ODAS (ONERA DLR Aerospace Symposium), which celebrated its 25th anniversary in 2024. Since then, cooperation has grown steadily: transport aircraft design, wind

tunnel measurement methodology, optical metrology to measure flows, etc. The two organisations have also developed a unique activity for aircraft ground vibration tests, and are also working together on a number of studies funded by the European Commission, notably on the decarbonisation of aviation (Clean Aviation).

GERMANY

IFAR and ONERA in the spotlight at the Berlin Aerospace Summit

The Berlin Aerospace Summit (BAS) is the Germany's leading aerospace event.

On the eve of the opening of the German Air Show (ILA), this event brought together stakeholders in the field at the highest level from European industry, research centres and German ministries. Bruno Sainjon, in his capacity as Chairman IFAR, was invited to introduce a panel on the future of aviation in terms of aircraft and new types of air mobility.

Visit from the Director of the German AID

At the request of the AID, the Director of the Research & Innovation Hub of the German Federal Ministry of Defense, Mr Alexander Schott, visited the Palaiseau centre. The aim was to deepen our exchanges in order to better understand our organisation, particularly through our interactions between ONERA and the DGA, and more specifically with the AID. Following presentations on the activities carried out in the fields of defense, civil aeronautics and radar R&T, two visits were made to the Simulation lab and the AID lab.

From left to right: Philip Trompke (RIH, FMoD*), Jara Cathrin Kürschner, Dirk Seebeck (RIH, FMoD), Marc Lesturgie (DAI), Franck Bilau (AID), Laurent Vieste (AID), Alexander Schott (RIH, FMoD), René Mathurin (DPD), Sylvain Schwartz (DPHY), Philippe Beaumier (DPA), Juliette Dubreuil (AID), LTC Matthias Wolfgang Mönch (RIH, FMoD), Sébastien Reynaud (DTIS), Philippe Dreuillet (DEMR), Lucile Ruiz (DPD).

*RIH, FMoD: Research and Innovation Hub, Federal Ministry of Defense



INVESTMENTS

Investing to building the futur

In 2024, major investments have been made with an objective unchanged since the creation of ONERA: to remain at the cutting edge of experimental know-how.

GRIFON PLUS (total amount of €0.90 M)

physics department

Complementing DGA-TA's lightning certification facility, ONERA's Lightning Impact Research Generator (GRIFON) studies the physics underlying the lightning phenomenon. The GRIFON PLUS investment operation aims to extend GRIFON's study capabilities (Roadmaps 1.1 Electric aircraft for on-demand mobility and 3.1 Tools and resources to support the certifiability of future aircraft):

- more electric aircraft (increased network voltage, cable wear, switchgear);
- new aircraft geometries: drones, airships (zoning to be redefined, lack of physical understanding).

The bench will enable lightning phenomena to be observed at representative levels, simulation codes to be validated and new sensors to be developed. Various characteristic lightning waves will be generated. In 2023, the acquisition of a generator (600 kV) with a variable waveform finalised the investment. New instrumentation (high-speed cameras, broad-spectrum spectroscopy) will also be installed in 2024





€3.02 M

MOSTRA

(total amount of €3.02 M€)

materials and structures department

The "Microscopy of Sensitive Objects with Reduced Accelerating Voltage and Corrected Aberrations" (MOSTRA) project involves the acquisition a cold cathode (30 - 200 kV) Transmission Electron Microscope with the CNRS, to replace two ageing microscopes that will no longer be maintained.

This cutting-edge equipment will be used to study high-performance alloys, alloy coatings, MAX phases and the graining treatment of non-linear crystal alloys, aeronautical soot, graphene and van der Waals heterostructures (Roadmaps 2.1 More efficient engines with reduced emissions and 10.4 Digital materials). The Ile-de-France region has agreed to provide €1 million in co-funding as part of the SESAME programme. 3 CNRS laboratories, including the CNRS/ONERA laboratory, the LEM (Laboratoire d'Etude des Microstructures) have committed €320k.

MOSTRA was built in 2023 and will be delivered to the materials and structures department at the Châtillon centre in the first half of 2024.

ROSALI

(total amount of €2.10 M)

theoretical and applied optics department

The lidar observation and atmospheric sounding research project (ROSALI) aims to design lidars to reduce the climate footprint of the aviation sector (Roadmap 2.3



€2.10 M

Environmental impact and climate change) and mastering the optronic and aerological scene for Defense (Roadmap 4.1 Onboard sensors for observing the Earth and human activity).

The first objective is based on the design of 3 demonstrator lidars: an all-altitude molecular wind lidar to measure the wind field upstream of an aircraft, a multi-spectral aerosol lidar to characterise aerosols in flight (condensation trails) and on the ground (engine emissions), and a combined CO₂ & wind lidar (flow measurement) to remotely measure CO₂ emissions from aero-port, urban or industrial areas.

The second objective is based on the design of two high-performance demonstrator lidars to characterise the atmosphere's radiative properties (aerosol scattering and absorption) and dynamic properties (wind field): a coherent wind lidar, in particular to eliminate the risk of the wind system on the new-generation aircraft carrier, and an HSRL (High Spectral Resolution Lidar) aerosol lidar to characterise the ground-space optical link and assess the emissions and stealth of engines and missiles.

In addition, the need to collect field measurement data has led to acquisition of 2 commercial lidars in 2022-2023: a bi-spectral wind lidar and an upgrade of the Leosphere wind lidar. Demonstrator components and laboratory equipment have been defined and ordered. The five lidar demonstrators have been integrated and will be implemented over 2023-2024

ONERAs CSR priorities: Results stakeholder consultation

As part of its Corporate Social Responsibility (CSR) approach, ONERA surveyed its stakeholders in October 2024 in order to rank its priority CSR issues. These issues will guide ONERA's CSR policy in the coming years.

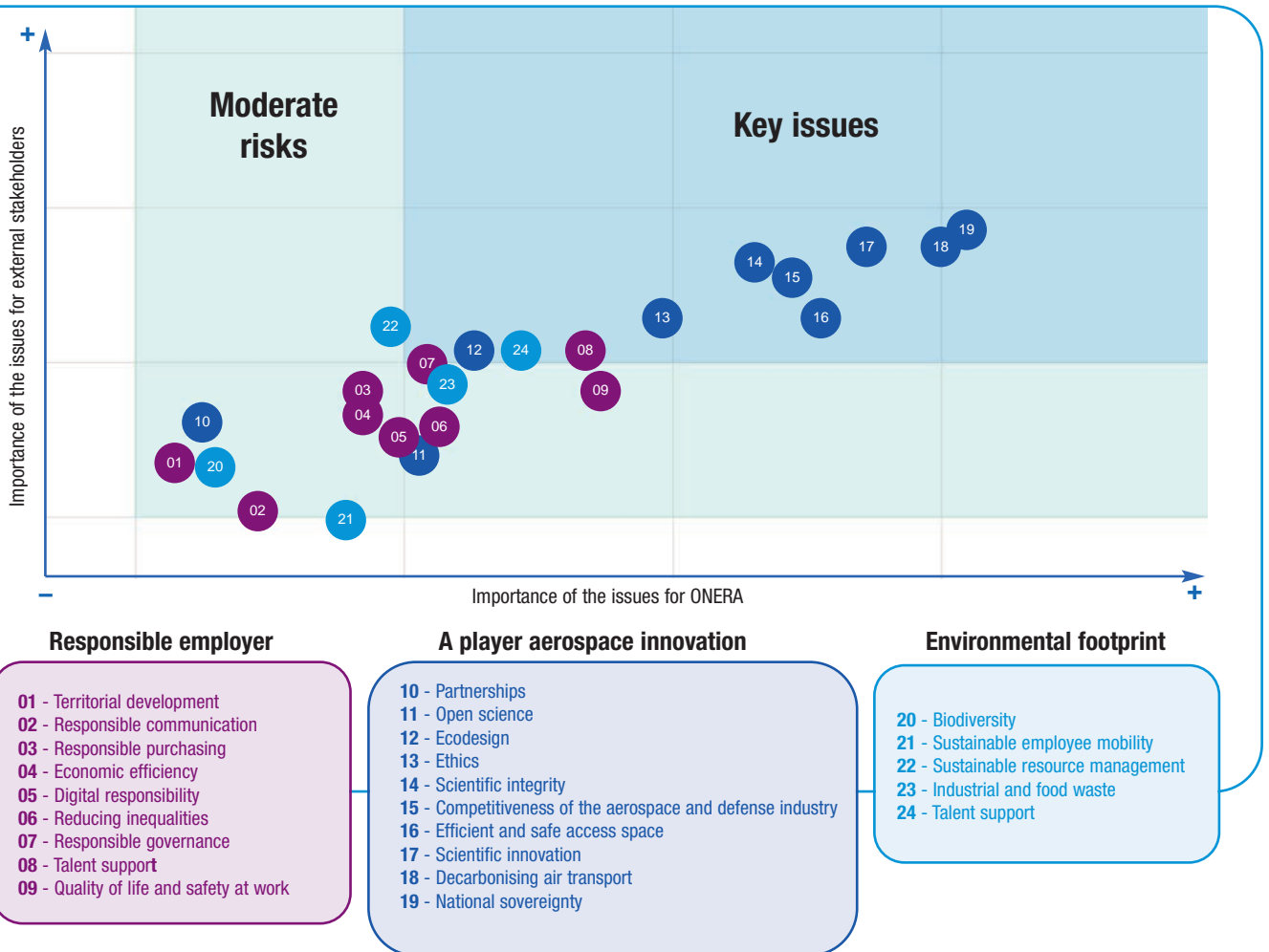
Identifying the issues at the heart of ONERA's CSR policy

To carry out this analysis, a questionnaire on 24 CSR challenges was distributed to internal and external stakeholders.

external to ONERA. Each issue was evaluated on a scale of 1 to 4 to assess its importance.

The results were then represented in the form of a matrix that prioritises the most strategic issues, including :

- National sovereignty,
- Decarbonising air transport,
- Scientific innovation,
- The competitiveness of the aerospace and defense industry,
- Efficient and safe access space,
- Scientific integrity.



Broad involvement of ONERA stakeholders

A total of 291 internal stakeholders (employees, managers, COMEX members) and 101 external stakeholders (Ministries, DGA, industrial and institutional customers and partners, the national and international scientific community, suppliers) expressed their views during the survey. This high level of participation testifies to interest in this

event and ensures the relevance of the results obtained. ONERA would like to thank all the employees and external stakeholders who took part in this important exercise. Thanks to this identification of priorities, ONERA can now define its future CSR policy, in order to meet the expectations of its stakeholders.

All major civil and military aerospace programs in France and Europe
have some of ONERA's DNA: Ariane, Airbus, Falcon, Rafale,
missiles, helicopters, engines, radars, etc.

Aircraft
Helicopters
Aircraft propulsion
Space transport
Orbital systems
Missiles
Drones
Defense systems
Security



In 2023, the certification audit led to the
renewal of ONERA's ISO 9001-2015
certification for 3 years.



6, chemin de la Vauve aux Granges
91120 Palaiseau – France – tél. : +33 1 80 38 60 60

www.onera.fr