ONERA, a central player in aeronautics and space research, employs approximately 2,000 people. Under the supervision of the Ministry of Defense, it has a budget of 230 million euros, of which more than half comes from commercial contracts. As a government expert, ONERA prepares tomorrow's defense, meets future aerospace challenges and contributes to the competitiveness of the aerospace industry.

It masters all of the disciplines and technologies in the field.

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. Its researchers, who are internationally recognized and have often received awards, train many doctoral students.
Editorial
Bruno Sainjon, Chairman and CEO of ONERA

Towards 70 more years of excellence

This message was clearly expressed during the celebration of our 70th anniversary in 2016, and this indeed reflects our situation at the end of this year. ONERA is based on a solid foundation constituted by its many contributions to defense, aeronautics and space during its 70 years of existence. Thanks to the renewed support of its state and industrial partners, and to the efforts that it has made, ONERA is moving towards a now clearer future, with a shared scientific strategy and ambition. This reaffirmed trust by our partners translates notably into an economic vitality that, although still fragile, is quite real.

On December 14, 2016, at the time of the signing of ONERA’s objectives and performance contract (COP) for 2017-2021, Mr. Jean-Yves Le Drian, Minister of Defense, stated that “ONERA is a true sovereignty tool”. This is a recognition, but also a challenge, which always demands the highest level of excellence from us. We do and will do everything to live up to the nation’s expectations of us. This COP reaffirms and strengthens ONERA’s missions. It is based on the Strategic Science Plan (SSP), also published in 2016, both documents being the result of iterative and collaborative work, both within ONERA and with our various partners. This SSP comprises a strategy structured into twelve scientific challenges. We will now define it in the form of roadmaps, in order to specify the lines of work in an evolutionary way.

ONERA has continued its openness towards its national or international partners. In addition to tightening the institutional links mentioned above, we have signed an agreement on remote sensing with Toulouse Métropole, as well as partnerships and agreements with the DCNS, SOPEMEA, Bertin Technologies, Safran Tech, etc. On the international level, we signed a new agreement with NASA relating to research aimed at reducing aircraft noise. We have also continued and developed, in particular through the signing of several agreements, our exchanges with our Russian, Singaporean, Japanese and European partners, etc.

As in 2015, we ended the 2016 financial year with a positive accounting result, this time for 4.8 million euros. This is again the result of the management efforts that we once again deployed. A steep increase in orders taken in 2014 was also confirmed in 2016, reaching 130.3 million euros, that is, a sharp increase of more than 23% compared to 2015, and more than 55% since 2013. This is a strong and tangible signal of the renewed trust by all of our partners. This year was also marked by the strong support from the Ministry of Defense, which mobilized the first part of the 20 million euros needed to preserve the S1MA wind tunnel, a truly strategic asset. This facility was threatened by the sinking of the ground, which could cause irreparable damage. ONERA immediately began the consolidation work which will continue for four years.

On March 1, 2017, we set up a new organization, prepared in close consultation with all of our employees. It is aimed at increasing our operational efficiency and internal dialogue, our visibility and our influence, including internationally. Three program lines have been created: defense, aeronautics and space. This change came as a response to a unanimous demand from our state and industrial partners and ONERA’s need to increase its capacity for dealing with cross-cutting issues.

We are proud of our 70th anniversary, and when Mr. Laurent Collet-Billon, the General Delegate for Armament, describes ONERA as a “spearhead of aeronautics and space research” his words go directly to our hearts. The celebration of this event on all our sites has given rise to numerous testimonies by celebrities and neighbors, as well as members of our families.

Finally, I would like to thank those Members of Parliament and Senators, who, as in 2015, expressed many testimonies, both of interest and support for ONERA’s work and achievements, and of recognition of the value of its employees. Encouraged by these signs of recognition, trust and friendship, ONERA is focused on the challenges of defense, aeronautics and space of the future. You can count on us for at least 70 more years of scientific excellence at your side.

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What is the SSP?

The SSP – or Scientific Strategic Plan – is the strategic guideline document for ONERA’s research activity. It is intended to provide structuring elements for the bases of multiannual objective and performance contracts. It takes into account the opinions and recommendations of ONERA’s Scientific High Council, external reports drafted at the request of official departments, and strategic meetings with government departments and industry. The SSP is a essential element of the dialogue with the state, the scientific community and industry. Today, it is divided into twelve scientific and technical challenges.

ONERA’S DNA

From basic research to technological development, from modeling to simulation, from experimentation to testing on real systems in flight or in large wind tunnels, it is this continuity of multidisciplinary research on aerospace and defense issues that constitutes ONERA’s true DNA. The SSP expresses this DNA in each of the scientific challenges, in favor of the Aeronautics, Space and Defense sectors.

TRL 2 to 6, the domain of the SSP

The SSP concerns the TRLs (Technology Readyness Levels, or degré de maturation technologique in French) of Level 2, the technological concept (the applications are still speculative) and, at Level 6, demonstration prototype production.

The SSP, an action tool

For ONERA, the SSP sets a stimulating course for the future: the aims and guidelines proposed must lead to new ideas, new technologies and new scientific fields. ONERA also wishes to develop transversality and partnerships, which have become necessary due to the complexity of the systems and their environment, and to the growing demands placed on future systems.

The SSP must thus contribute to the setting of ONERA’s annual objectives by providing a long-term vision of them and by enabling the definition of the indicators most relevant to its ambitions.

The SSP, a global vision beyond ONERA

To accomplish the mission entrusted to it by the State, ONERA must position itself not only as a major actor in research, but also as a center for rendering research consistent. Given that from now on research at low and medium TRL can only be collaborative, a global vision is essential. ONERA intends to play an essential role in this.
Key figures

2016 investissements: 21.3 million euros (15.3 million euros in 2015)

ONERA has a complete and varied range of experimental facilities, suitable for each stage of the research process. These facilities require constant renovation and maintenance effort, for ONERA to maintain its level of excellence.

In 2016, ONERA dedicated 4.7 million euros to the reinforcement of its S1MA wind tunnel in Modane.

Purchases

ONERA works predominantly with SMEs at all its centers, in all regions as a whole.

Purchases by type of company 2016

- SME (< 250 employees): 67.8%
- 250 to 500 employees: 4.5%
- Large companies: 2.7%
- Public institutions: 1.1%
- European Union: 5.9%
- Third countries: 18%

Regional distribution of SME partners

- Île-de-France: 64.4%
- Occitanie: 15.30%
- Auvergne-Rhône-Alpes: 14.76%
- Hauts-de-France: 2.88%
- Provence-Alpes-Côte d’Azur: 2.65%

A budget of 235 million euros

105 million euros in GPSC (Grants for Public Service Charges)

130 million euros in contracts won

15 million euros in funding for the S1MA

2016: steep increase in orders

Contract business by field in 2016
Human Resources

Training future researchers

Training through research is one of the seven missions included in ONERA’s statutes. In return, for its scientists, it is rewarding to train doctoral candidates, post-doctoral candidates and interns because they offer a way to refresh ideas and methods. In 2016, ONERA had 238 doctoral candidates, and 73 theses were sustained. To supervise them, it has 88 doctors with HDR (habilitation à diriger des recherches, accreditation to supervise research), that is to say, engineers with sufficient professional and scientific background for mastering a research strategy in a scientific field, to mentor young researchers.

1,985 COLLABORATORS

1,476 ENGINEERS & MANAGEMENT STAFF
238 DOCTORAL CANDIDATES
234 INTERNS
24% WOMEN
87 NEW HIRES
INCLUDING
49 ENGINEERS AND MANAGEMENT STAFF

Articles published in peer-reviewed journals: 291
Papers submitted for peer-reviewed conferences: 403
Technical reports: 1228
Post-doctoral candidates present: 24

Scientific awards

MBDA-France Innovation Awards for Jean Perraud and the Garteur AG51 Group, for their work on hypersonic transition coordinated by ONERA.

Gold Award from the Royal Aeronautical Society for the article “Distributed propulsion and ultra-high by-pass rotor study at aircraft level”, by Richard Grenon, Olivier Atinault and Jean-Luc Godard, published in The Aeronautical Journal of November 2015.

Luc Vignaud received the SET Panel Excellence Award at NATO’s 38th SET Panel Business Meeting de l’OAN.

Maxime Bouyguès, François Chedevergne and Grégoire Casalis received the award for the best article worldwide on solid propulsion from the AIAA for their article “Local Linear Stability Analysis of Non-Circular Injection-Driven Channel Flows”.

Marc-Paul Errera, Marc Lazareff and Tristan Soubré (Andheo) received the scientific excellence award from 3AF for their work on innovative numerical approaches to Aerothermal Coupling.

Best paper awards

Best Paper Award for the article “Predictable composition of memory accesses on many-core processors” by Quentin Perret (Airbus and ONERA), Pascal Maurère, Benoît Triquet (Airbus), Éric Noulard, Claire Pageli (ONERA) and Pascal Sainrat (IRIT) at the ETSS 2016 conference (Embedded Real Time Software and Systems).

Best Student Paper Award for Kevin Cossu (CIFRE thesis Thales Optronique, ONERA) and presentation of his work on the study of very compact cooled infrared cameras with 3D vision capability, at the OPTRO 2016 conference in Brussels, in April 2016.

PhD Student Best Paper Award for Kevin Cossu (CIFRE thesis Thales Optronique, ONERA) and presentation of his work on the study of very compact cooled infrared cameras with 3D vision capability, at the OPTRO 2016 conference in Brussels, in April 2016.

Best Paper Award for the article IED Schedulability Test for the E-TDL Time-Triggered Framework by Thomas Könda, Luca Santinelli and Bruno d’Ausebou, at the 11th international symposium of the IEEE “Industrial Embedded Systems” (IES 2016).

1st Place Student Paper Award for Flora Weisgerber at EuGRAR 2016 - 11th European Conference on Synthetic Aperture Radar for her paper: “Resolution enhancement of polarimetric images using high resolution mono-channel images”.

Ilan Petroopoulos, an ONERA doctoral candidate, received the Young CFD Investigator Award for his paper “Development and Analysis of High-Order Vorticity Confinement Schemes”, during the 9th International Conference on Computational Fluid Dynamics in Istanbul in July 2016.

The article “Application of electromagnetic topology and power balance concepts to radio frequency couplings into buildings” earned its authors, Isabelle Junqua, Jean-Philippe Parmantier, Wilfrid Guenon and François Issac, the Best Applied Paper Award 2014-2016 from the Summa Foundation during the EuGEM 2016 conference.

Florian Mahdiddini received the award for the best student article for “Coupled EMC Thermal Modeling of Electrocal Harnesses Within ‘More Electrical Aircraft’” at the ICAS 2016 congress (Daejeon, South Korea).

Jean-François Nouvel, Xavier Dupuis and Marc Lesturgie received the 1st Excellence Award at the Radar 2016 international conference (Guangzhou, China) for the paper “Non-Line-of-Sight signal analysis: investigation of interferometry modes over urban area.”

DISTINCTIONS

Delphine Bonnaud
The Aeronautics Medal
by the decree of
09/27/2016

Anne Denquin
Named Knight of the National Order of Merit
by the decree of
05/13/2016

Sylvie Plot
Named Knight of the National Order of Merit
by the decree of
11/14/2016

Virginia Wiels
Named Knight of the National Order of Merit
by the decree of
11/14/2016

Hervé Consigny
Named Knight of the Legion of Honor
by the decree of
12/30/2016

Benjamin Riverie, recipient of the 2016 award of the École Doctorale “Génie électrique, électronique, télécommunications : du système au nanosystème” for his thesis on the study and design of antenna arrays with very large bandwidth.

Maxime Itasse received the 2016 thesis award (École Doctorale EDyF - Énergie et dynamique de fluides), from the ISAE-Supélec foundation for his thesis: “Effet sur le bruit de jet de l’exécution de modes instables : rôle des interactions non linéaires” (Effect on jet noise of the execution of unstable modes: the role of non-linear interactions).

ÉCOLE POLYTECHNIQUE THESIS AWARDS

Guillaume Point, for the deposition of energy in the air by femtosecond laser filamentation for controlling high-voltage discharges.

Paul Chevalier, for the hyperfocusing of light through sub-wavelength length structuring.

DGA INNOVATION FORUM THESIS AWARD

Florian Maire received the 3rd awards for his thesis on the detection and classification of multispectral targets in infrared.
International mobility

Paul-Quentin Elias, Physical Measurement Scientist sent for one year to the University of Los Angeles (UCLA)

My personal aspirations corresponded to ONERA’s needs

A CLOSER LOOK AT THE RPS AGREEMENT

whose goal is to reduce stress factors at work. Several actions have already been carried out in 2016 involving DRh, the managements of the centers and representatives of the staff.

Meetings of expression groups

Each department, division and unit organized a meeting to encourage employees to express their concerns, directly and collectively, on the work and the conditions under which it is carried out.

ONERA’s internal good practices guide

It has been distributed to all of the staff and will be distributed to all new hires. Developed jointly with the staff representatives, it reaffirms that ONERA is a human community that revolves around the values of respect, sharing, trust and balance. Each contributes to the well-being of all and can play a role in improving human relationships.

Psychological support line

An anonymous and confidential telephone support hotline has been set up to enable employees to deal with any personal and/or professional situations that concern them. A line is accessible 24/7. An assessment, in the strictest respect of anonymity, will be presented to ONERA’s management, so that it can implement corrective and preventive actions if necessary.

Other actions built in 2016 will be deployed in 2017, such as training courses or workshops to discuss best practices. The thread will not change: management wishes to ensure that everyone has the right tools and contacts to promote well-being at work.

A survey is also planned to initiate an in-depth analysis of the psychosocial risk factors and the definition of the related prevention plans.

Without the support of the DGA, my visit would not have been possible

Claire Pagetti, Information Processing Scientist, sent for one year to the Hamburg University of Technology

Thanks to a DGA scholarship worth nearly 33,000 euros, Claire was able to finance her visit. ONERA of course guarantees that her salary is maintained, but the cost of real estate in Hamburg is so high that the financing by the Ministry of Defense is indispensable. On the other hand, the legitimacy of the approach was essential: Claire works on the predictable programming of massively parallel architectures (for example, multiple-core or plural-core), a subject for which a powerful computing environment is required. “Only the Tuhh has IT tools that allow both the integration of ONERA solutions and easy use for any future user.” Indeed, for aeronautical control-command applications, regardless of the aircraft, it is necessary to be able to calculate time’s and timing latencies in a reliable manner. In this context, mobility “to acquire elsewhere skills that one did not have here” was not only conceivable but also desirable, in the opinion of ONERA and the DGA.

WOMEN’S ENGINEERING SCIENCES: A FIRST IN ONERA

In November 2016, the project “Women’s Engineering Sciences” was held in France, at the initiative of the “Elles bougent” associations and of the Union of Science and Industrial Technique Professors (UPSTI).

While female ONERA scientists, technicians and doctoral candidates presented their backgrounds and areas of competence at nine schools close to our sites, forty teenage girls from the colleges and the Lycée des Ulis (ZEP in Essonne) were welcomed at Palaiseau.

By participating in this initiative, which is aimed at attracting young girls to scientific professions, ONERA is showing its support for it. It marks its desire to further favor the diversity within its research teams.
A closer look at 70 years of success in aerospace

The Airbus range or Rafale? Helicopters or drones? Laser imaging or surveillance radar? Launchers or satellites? It is impossible to choose, ONERA’s science has spread its technological advances everywhere! Often invisible, yet essential! It is on this basis that ONERA celebrated its 70th anniversary in 2016.

In 1946, World War II had emphasized the importance of the air force, and France created a national research center for the aerospace sector, ONERA. Its purpose: to make research a national sovereignty factor, and to help French industry meet the scientific challenges to prepare the skies of tomorrow. 70 years later, it is clear that the gamble has been won: ONERA has participated in the greatest aerospace successes!

The big exhibition “70 years of ONERA” has traveled: Hauts-de-France, Ile-de-France, Occitania, and Auvergne-Rhône-Alpes; each region with an ONERA center was able to host the exhibition, so that all ONERA engineers-researchers could celebrate this anniversary with pride, since they have written (and are still writing) a part of the history of the French aerospace industry! This is a success that is also celebrated by the many local representatives, aware that ONERA centers play a key role in the political and economic ecosystem of their region. The story continues…
JANUARY

First light of Gravity, the ultimate interferometric instrument of ESO / VLT

A world premiere at ESO in astronomical optical interferometry. ONERA has been involved as from the design of Gravity in the definition and optimization of the servo-control subsystem of the phase between the telescopes, one of the keys to the success of the infrared instrument for the study of the vicinity of the black hole at the center of our galaxy.

Installation of a neutron spectrometer in Antarctica

This measurement station will enable ONERA to have the world’s first neutron spectrometry network dedicated to the study of the atmospheric natural radiative environment. This network will contribute to the development of a global model for the analysis and quantification of the effects of atmospheric radiation on embedded systems and biological cells.

Ariane 6 aerothermal tests in ONERA burst wind tunnels

The engineers of Airbus Safran Launchers need to know the local heat flux to properly calibrate numerical aerodynamic and aerothermal models, to refine the design of the launcher, and to respect the “heat wall” limits. At ONERA, the research wind tunnels and the supersonic and hypersonic specialists meet this demand.

This Rapid project (cofinanced by the DGA) is aimed at developing a flight simulator prototype for the LCA 60T Large Capacity Airship, 60 tons. It confirms ONERA’s expertise in the field of airships and strengthens its partnership with the SME Flying Whales.

A first in ONERA’s wind tunnels: lidar velocimetry

A Doppler lidar developed by ONERA was deployed in the L2 wind tunnel in Lille, in order to develop 3D aeroelastic field reconstruction tools by hybridization of numerical and experimental data. The ultimate goal: to transpose the measurement principle to Scale 1, when PIV is not suitable. This is an ONERA research project.

“Nightglow” measurement campaign to gain knowledge about the upper atmosphere

A team from ONERA traveled to Reunion Island to analyze the dynamics of the upper atmosphere using nightglow infrared radiation produced there (European project Arise2). This low illumination close to the visible range making night vision possible is also a subject of great interest for defense applications.

MARCH

ABISS, a new generation space surveillance radar

The European bistatic radar ABBSS, developed by ONERA for ESA, can detect space objects measuring one meter in diameter – debris or satellites – at an altitude of 350 km. During a demonstration, ABBSS was able to track the ExoMars probe in its transfer orbit as it passed over Europe. Its performance is excellent.

Laminar technology for regional aircraft

The aim was to show – within the framework of the European program Clean Sky – that a wing designed by ONERA had a large laminar expanse in cruising mode. The challenge: to greatly reduce drag. With a 5.2 m model in the S1MA wind tunnel, measurements with infrared cameras and a flow with variable temperature, very conclusive tests were achieved. This will be continued in Clean Sky 2.

ONERA 2nd out of 323 in NASA’s ATM challenge “Sky for All”

A team of three ONERA researchers was awarded the second place (out of 323 from 39 countries) in the “Sky for All” challenge, where NASA launched the challenge of imagining airspace in 2035 and designing an efficient and safe air traffic management system. ONERA thus gained international visibility in terms of prospective air traffic management.

APRIL

Platform operation around the elsA aerodynamic simulation software

The maturity of the hybrid approach – the coexistence of structured and unstructured areas – in the elsA software program motivated ONERA, Safran, Airbus and Cerfacs to intensify their development relations by initiating a platform operating mode. The goal: to stimulate collective intelligence, to decompartmentalize competences and to strengthen relations between the partners.

Innovative measurements for radar-wind turbine compatibility

ONERA carried out, with its mobile radar Medycis and the support of the Ademe, a measurement campaign on a wind farm in production. This made it possible to quantify certain aspects of the radar disturbance generated by wind turbines. These measurements were for the first time calibrated with a mini-drone bearing a standard radar reflector.

ONERA supplies ultra-sensitive space accelerometers to NASA

ONERA delivered to NASA the three flight models of the Grace-Follow-on accelerometer. Grace-FO is to succeed the Grace mission (already instrumented by ONERA), which has been in orbit since 2002. Its objective is to follow – through this instrument – the changes in the Earth’s gravity field, and to provide information on climate change, such as the progression of the melting of the ice caps.
ONERA has used iBESTA – its air transport system evaluation platform – to test the Dynamic Airspace Configuration (DAC) simulation concept developed by the European program Sesar. The operational experts appreciated the exercise, which made it possible to demonstrate the benefits of the concept for balancing the workload between air traffic controllers.

"Flight intelligence" demonstration in a SNCF workshop

An ONERA team demonstrated scenarios representative of operational conditions in the use of small drones for the inspection of indoor structures. This work, carried out within the framework of the research-industry partnership between ONERA and SNCF, perfectly answers the problem of complete automation of the flight desired by the SNCF.

Cooperation between test pilots and researchers on Helicopter Pilot Assistance

Test pilots from the DGA-EV and the EPNER School participated, together with ONERA researchers, in the definition and development of return force laws that enabled the validation of a new type of interface: in the presence of an obstacle that is too close, the helicopter pilot feels displacements of the stick that incite him to move away from danger.

In-flight refueling of helicopters by the A400M

Airbus Defense and Space requested ONERA to study the behavior of the helicopter in-flight refueling device with the A400M aircraft through wind tunnel tests. Measurements using laser optical methods (PH) have confirmed the aerodynamic relevance of the configurations tested.

ONERA invents a heat flux measurement method using liquid crystals

ONERA has acquired, with Safran, a furnace capable of achieving up to 1250°C under a pure hydrogen atmosphere and enabling desulfurization through an ONERA process. This investment supports the development of monocrystalline alloy systems coated with thermal barriers for the next-generation HP turbine blades that will equip the Mi8/ Mi17 mid-life, as well as those of the TCAS.

ONERA and Sopexa join forces to master modal analysis

ONERA and the Sopexa company have entered into a partnership agreement to share their expertise on modal identification and aircraft ground vibration testing (GVT). ONERA develops and implements means and methods specifically for carrying out tests for all types of aircraft; Sopexa carries out tests for aircraft, and also in other fields: railroad, energy, …

Air inlet tests on a three-engine Bizjet model

Within the framework of Clean Sky, a test designed to quantify the efficiency and distortion levels at the inlet and central engine inlet was carried out in the large S1MA wind tunnel. Various positions of the nacelles with respect to the fuselage were tested, including a configuration with ingestion of the boundary layer (RIL), designed by ONERA aerodynamics to improve propulsion efficiency.

ONERA develops a global model of the radiation belts

Based on the experience gained from in-situ radiation measurements and local specification models, ONERA has developed a first version of a global model, gathering the various local models available. This model, more accurate than those of the 1970s and 1980s, responds to the industrial demand for dose calculations (electron and proton fluences) on a mission.

Bertin Technologies and ONERA create a joint laboratory

This three-year research-industry partnership is aimed at developing a new generation of multispectral cameras for remote sensing of gas. The innovations produced will equip Berlin’s next remote sensing devices for the energy industries.

First in-flight tests of steering-guidance laws for the automatic landing of self-guided packages

ONERA has validated, on behalf of DGA Techniques Aéronautiques, a set of functions necessary for performing the automatic all-weather landing of self-guided packages. Experiments in flight on a mini-parasite have thus made it possible to test the relevance of the steering-guidance laws intended to improve precision.
ONERA designed and developed the Graves system, which provides France with a space surveillance system that is unique in Europe, enabling the Air Force to track and catalog satellites since 2005. This year, the DGA renewed its confidence by awarding it the contract for the renovation of the system, as well as to Degreane Horizon. This new contract will allow it to extend its service life until 2030 and provides for improvements in performance. In November 2016, ONERA and Degreane horizon were entrusted by the DGA with the contract for the renovation of the Graves system, in order to perpetuate it and increase its performance. Today, the main mission of the system is military intelligence through the development of the space situation: it enables the Air Force to track and catalog satellites operating in a low orbit up to an altitude of 1000 km. Totally autonomous in the elaboration of this catalog, the system thus makes it possible to calculate at any instant the position of the satellites monitored.

What does the new contract provide? Thanks in particular to interventions on the reception antennas and to signal processing integrated on a new computer, as well as enhanced operation, its performance will be increased. ONERA will be in charge of the renovation and improvements of the receiving and operating sites and will be in charge of maintaining the performance of the system and then extending it. Degreane Horizon will be responsible for the renovation of the broadcast site.

A pledge of confidence in ONERA, also included in the ‘objectives and performance’ contract signed in December 2016: “ONERA will continue its efforts to modernize and develop space surveillance systems (Graves), as well as early warning systems, both based on satellites such as Spirale and on long range and trans-horizon radars.”
ONERA in the service of the State for a wide spectrum of activities concerning drones, from their design to the evolution of their capacities and their uses, as well as the problems that they pose to society. ONERA has mastered all of the disciplines of defense aeronautics: multidisciplinary design, artificial intelligence, aerodynamics (including in extreme conditions), technical issues raised by changes in regulations, certification tools and their evolution, radar optronic sensors, and adaptation to constraints and to the environment.

Experimental and numerical means and the skills of technicians and research engineers are used to create and test technological breakthroughs, to explore new possibilities and to pave the way for new applications.

Collection of the year 2016 …

ONERA’s expertise in defense drones began in 2000 with the Halerte project, a system engineering tool designed and implemented throughout ONERA to enable a multidisciplinary approach to the design and evaluation of the high altitude long endurance. Halerte was based on a network of experts working cooperatively. Multidisciplinary design became one of the strengths of ONERA.

ONERA an expert in drones for defense and security

FCAS-DP
Future Combat Aircraft System Development Program – ONERA is directly involved in stealth, engine (high temperature) materials and decision-making autonomy. ONERA is also preparing this program for the future through research with its own funding. It also benefits from the experience of the research carried out for the pan-European demonstrator Neuron.

Adac
Decision-making autonomy of combat aircraft – Preparing to provide answers to questions that will arise in the development of the FCAS-DP program: choice of decision-making methods, solutions for interaction with human beings and integration into avionics. Project financed with own funds.

Ethicsa
Ethics and autonomous agents – Equipping robots, including drones, with ethical behavior since they are increasingly autonomous and less and less controlled by human operators. Objectives: a formal representation of ethical principles and conflicts, and models of automatic reasoning to be able to manage them, validated on real world scenarios. Project funded by the ANR.

ExdroMale
Technical Experiments on MALE (medium altitude long endurance) UAV systems – for the government.

ERA
Enhanced RPAS Automation – Developing advanced features and preparing for standardization. By ONERA: work on modeling and steering for taxiing on the ground, multi-source data fusion for the detection of obstacles on the ground, or even radar/inertia fusion; technical expertise in support of standardization. European Defense Agency, steered by Airbus DS.

Angelas
Overall analysis and evaluation of technologies and methods for the fight against UAS (drones) – [ANR, SGDSN] – Coordination and expertise of “UAV systems” including know-how in the field of sensors (optronic, electromagnetic and acoustic). Detection-tracking, classification-identification and multi-sensor fusion. Demonstration carried out in November 2016.

Aeroceptor
Stopping a non-cooperative moving vehicle from a drone by various means. ONERA contributions: electromagnetic payload for stopping the vehicle; following of a vehicle by a drone, including cooperatively with two drones (rotating and fixed wings). European project FP7.
How will a missile behave in a given environment? In a theater of operations, how will the reverberation of snow, swell, or topography affect the weapon system? Thanks to its fine mastery of physics, and thanks to previous work on the subject, ONERA knows how to integrate the fine parameters of the sensor environment into its simulation work. Indeed, ONERA has developed a recognized expertise in the modeling of physical processes that drive or affect the signals “seen” by sensors (natural or artificial backgrounds, effects of atmospheric propagation, target signatures, etc.).

In June 2016, the DGA and ONERA set up a framework agreement formalizing the role and scope of intervention of the “environmental benchmark”. As the conductor of the sector, it plays a pivotal role between state, industry and research world, to identify needs and to build a roadmap. To ensure this role, ONERA therefore has many partners, including Météo France, GéoMé, Alyotech, Oktal-SE, university laboratories, etc.

As early as 2014, the DGA retained ONERA as coordinator of the simulation master plan. ONERA has developed numerous environmental models, including the calculation of radiation transfer and meteorological predictions. It may also, in a complementary way, use its ground or airborne experimental means for the acquisition of model input data and for validation.

Simulation is on the way to becoming a major tool for eliminating the risk of future armament programs. With its precise knowledge of physics, ONERA integrates all of the environmental elements surrounding the sensors of future systems (optical and electromagnetic environment) into its simulations. In 2016, in order to increase the performance of the simulation and develop the capabilities of the new sensors, the DGA turned again to ONERA making it the national environment benchmark. A framework agreement was signed and the contract for the first studies was thus awarded to it.
ONERA operates a set of ten large aeronautical wind tunnels that are unique in the world. The effort necessary for them to survive and maintain their operational capacities is essential for the supervision of ONERA, which has provided 20 million euros for the reinforcement work on the large S1MA wind tunnel at Modane. An acknowledgment of the strategic nature of the ONERA wind tunnel, which contributes to the preparation of future weapons systems and the export of war materials. Legitimately recognized internationally as key tools combining science and industry, they are also a decision-making aid for industrialists.

Before the National Assembly, Jean-Yves Le Drian, Minister of Defense, announced on March 2, 2016, the launching of the consolidation work on the large ONERA-S1MA wind tunnel in Modane. The DGA made an investment subsidy of 15 million euros in 2016. 5 million euros will also be paid in 2017.

Objective: to reinforce the S1MA wind tunnel, unique in the world for its size and power, since it simulates cruise speeds close to the speed of sound on large models.

The work, which is very wide in scope, will put an end to the phenomenon of sinking, observed since the beginning of the life of the wind tunnel, and which has become greater since 2009. ONERA has identified a consolidation solution with specialized companies and has established a four-year work schedule.

In addition to the S1MA ground reinforcement work financed by the DGA, ONERA also received two repayable advances of 4,450 million euros from the DGAC1 to finance major upgrades to its main wind tunnels.

The first concerns the MORPHO project, amounting to 1.5 million euros, and deals with the complete overhaul of the wind tunnel information systems. The software architecture, defined with the AKKA Technologies group through an ONERA investment, will completely modify the interactions of the operators with the system. This new information technology will facilitate the acquisition, processing, transfer and storage of test data: ONERA’s current information systems will thus be more suitable for the new requirements of the users of the wind tunnels.

The second agreement is for the replacement of the 22 blades of the two counter-rotating fans of the S1MA blower. The new hybrid steel and composite blades will be installed in 2017. More efficient and superior, they will require much less maintenance and repair work.

This financial support from the DGA and the DGAC helps to upgrade the wind tunnel infrastructure and their testing facility environment. They will be able to accompany industrialists and state actors over a newly secured time horizon, to explore groundbreaking aircraft configurations.

1 Direction générale de l’aviation civile (French Civil Aviation Authority)
Today, airplanes are safe, safety being a prerequisite for which no compromise is acceptable. At the same time, in the coming decades, technological change will make aircraft more complex. With increasingly more embedded software, how can they be certified? As an expert in avionics software and an expert on standards in this field, ONERA has received 2 million euros from the DGAC to study for four years the technical and methodological challenges posed by the certification of embedded software functions. This is the PHYLOG agreement.

The avionics of the future will undoubtedly be more complex than those of today. Indeed, the next generation of aircraft will include new types of processors, called multi-core, which due to their greater complexity will be more difficult to certify. Why? Because it will be necessary to ensure that all of the scenarios have been envisaged: of the billions of possible executions, none must be erroneous.

ONERA has two assets to work on the changes in the certification of these new avionics. On the one hand, it possesses expertise in avionics software thanks to prior work initiated since the end of the 90s. On the other hand, it has knowledge from texts and certification standards in this field, developed in 2011, since it participated in their development within the Certification Committee (Formal Methods Supplement to DO-178C and DO-278A).

In order to maintain the current high level of safety in tomorrow’s aircraft, the DGAC has turned to ONERA to anticipate the complexity and to put in place the methods necessary to master it. By 2015, ONERA and the DGAC had signed four agreements on research programs. Not about software complexity, but rather about the complexity of the phenomena related to the environment of the aircraft: PHYWAKE dealt with wake vortices; PHYSAFE with crashes; PHYLIGHT with lightning and PHYSICE with icing.
The mission of ONERA, the State Expert, is to prepare the future of military aeronautics. Successfully, it has been constantly optimizing monocrystalline superalloys and the thermal barriers that protect them. The aim is to make the engines more resistant and more efficient. In 2016, Safran and ONERA launched the AGATHE program to improve the resistance of the blades to the extreme temperatures in turbine inlets. It was a rich year, since ONERA invested in new equipment to carry out its advanced experimental studies.

How can we ensure that the alloys composing the turbine disks and blades of the engines will durably resist an extreme environment during missions? While the subject returns to the front of the stage with the preparation of future military aircraft, Safran naturally turns to ONERA to take up this technological challenge. ONERA is a leader in the development of materials for very high temperatures and in the prediction of the lifetime of parts, and is in charge of all the stages: the design of the materials, their manufacture, their characterization and the modeling. Studies aimed at understanding the complex mechanisms are essential for the development of lifespan models conducted by ONERA, because they allow the sizing of the parts by Safran.

In 2016, ONERA acquired two new installations, including a four-cylinder biaxial fatigue machine, to test the resistance of materials for engine and airplane cell applications. Unique in France, it allows traction-compression loads up to 250 kN per axis to be applied, and temperatures up to 1000°C. ONERA also inaugurated the Castaing laboratory this year, dedicated to scanning electron microscopy and fine microanalysis of materials.

High temperature materials have always been a major focus for ONERA. Thus, the studies carried out on monocrystalline superalloys for blades and those resulting from the metallurgy of disk powders led to their introduction during the 1980s into the turbine of the Rafale M88 engine. The saga continues...

1 AGATHE : The Advanced Gas Turbine Project with High Efficiency is funded by Safran Aircraft Engines. ONERA is a subcontractor.
To master the increasing complexity of embedded systems, we can focus on the operation of the machine. However, one can also endeavor to understand the functioning of human cognition. ONERA is increasingly investing in this research area: in 2016, under the DGAC-funded PIA SEFA, it began work on spatial disorientation. Thanks to its LabSim environment, it enriches its solid database to interpret pilot behavior.

Automation can facilitate the work of pilots provided that it respects certain principles of interaction. To assist man in these complex tasks, it is essential to understand the operation of the operator in a situation. ONERA, increasingly better equipped, conducts many experiments.

The first step is to reproduce the flight conditions as faithfully as possible, which is made possible by the LabSim laboratory, located at the ONERA center in Salon-de-Provence. It consists not only of a simulator in the form of a cockpit with realistic flight mechanics codes, but also of prototyping means, implemented by ONERA engineers: visual, auditory or haptic tools (motorized sticks simulating return forces). This rare equipment reproduces exactly what the pilot sees, hears and feels.

The second step, but not the least: how can the behavior of the pilot be recorded in simulated flight situations? It is on this point that ONERA distinguishes itself: it has all of the necessary means to record the pilot’s reactions thanks to kinematic sensors detecting the movements of the body and the eyes, the electrodermal response and even the activity of the nervous system (electrical and metabolic), both peripheral (the muscles) and central (the brain itself).

Accustomed to pushing the frontiers of knowledge, ONERA works in the field of human factors with its entire ecosystem: industrial (Thales, Airbus), institutional (DGA, DGAC), operational (air force, land army) and academic or university (CNRS, AMu, ENSE, ISAE, etc.).
How can the performances of several prototypes of monergol be characterized experimentally under conditions close to those of their application environment? In other words, how can we analyze the reactions of potential new fuels on a model? ONERA was chosen to test a monergol formulation based on original ionic liquids, developed by the University of Lyon 1 (LHCEP) since 2013.

This liquid offers optimized physicochemical properties and new performances. Initially, ONERA will develop a suitable thruster that will analyze the behavior of the new green fuel. It will carry out the three complementary and indispensable steps.

The first is based on the knowledge of the intrinsic characteristics of monergol – thermal stability, flame velocity, and kinetics of chemical decomposition – in order to guarantee the safety of the stages linked to the development of the sector, and, on the other hand, to acquire critical data for the optimized sizing of the thruster.

The second step concerns the development of an ultra-high-temperature material suitable for the severe operating conditions induced by the combustion of this new monergol. Tests on dedicated means representative of the flow in a propellant will be carried out, in order to validate the material and its manufacturing process.

The last step is aimed at sizing the thruster by multi-parameter optimization (performance, thermal and structure) through a cross-analysis between numerical simulations and data acquired from a cooled model. In the long term, the developments will make it possible to converge towards a research demonstrator under real conditions, at a high level of TRL3.

Today, space also has to respond to environmental considerations. For these new specifications, ONERA, as it has been doing since the promotion of space developments wanted by General de Gaulle in the 1960s, will help to position France and Europe as major players on the subject.

By 2020, the European legislation REACH1 will be phasing out the hydrazine-based fuels currently used for satellite propulsion. In order to anticipate this change, the CNES and ONERA signed in 2016 a project of common interest (PIC) with the aim of developing and qualifying a "green propulsion" sector. ONERA has the necessary skills and test facilities to fulfill this mission, in accordance with its strategic science plan (SSP):

1 European Regulation on the Registration, Evaluation, Authorization and Restriction of Chemicals

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2 Laboratoire hydrazine & composés énergétiques polyazotés: Hydrazine Laboratory & Poly-nitrated Energetic Compounds

3 Technology Readiness Level
In order to test the universality of the free fall of bodies with unparalleled precision, the satellite must compensate for all forces that would deviate from its gravitational drop path around the Earth: residual air friction, magnetic torques due to the Earth’s magnetic field, or the pressure of solar radiation. The performance of this compensation measured in flight is unique.

This satellite has thus become a new world reference in low orbit. ONERA played a major role in this: Pierre Touboul is co-responsible for this mission.

In addition, ONERA provided a set of two differential accelerometers, these are tools offering incredible sensitivity to the instrument: this made it possible to detect on measurement the gravitational effect of the decentering of the test masses by a few micrometers, as well the effect of the variation of the photon pressure of the Sun on the satellite. The control of the levitation of the test masses in flight is of an incredible precision: the relative position of the two test masses is maintained with an accuracy on the order of the size of the hydrogen atom, a millionth of a hair!

Starting in November 2016, the satellite began its scientific tests for 18 months: a time required to obtain a high measurement accuracy and good repeatability.

The principle of equivalence currently being tested with MICROSCOPE enabled Albert Einstein to develop, between 1907 and 1915, his great theory of general relativity, revolutionizing Newton’s gravitation laws. MICROSCOPE’s challenge of achieving 100 times better precision than all experiments carried out on Earth would open up new horizons to gravitational theories.

The MICROSCOPE satellite has just successfully completed its first in-flight acceptance tests, which have yielded extremely promising results. The scientific mission, whose main researcher is Pierre Touboul, who is in charge of the mission within the general scientific management and scientific director of ONERA until 2016, is larger to test the validity of the principle of equivalence in space. Equipped with the on-board instrument T-SAGE, developed by ONERA, the satellite has thus begun its many measurement sessions, which could challenge the founding principle of the general theory of relativity proposed by Albert Einstein.
Transferring knowledge to another sector is something that ONERA does regularly. Transferring technologies developed for astronomy and defense to the medical field was more daring. It was the crazy bet of an ONERA optical team. Today, it is a reality: as the sole technological partner, ONERA’s Quinze-Vingts1 laboratory has just obtained funding of nearly one million euros as part of a PIA2, by the vision institute. This success is in addition to the result obtained at the best international level by the ONERA team, thanks to a video of blood circulation around the optic nerve.

In the 1980s, while the theoretical principle of adaptive optics was well known, the necessary technology was not yet mature. ONERA therefore developed methods to quickly correct atmospheric turbulence to observe stars. From astronomy to defense for airspace surveillance, ONERA wished to capitalize on its mastery of corrective techniques in order to propose methods for the medical sector.

The principle is simple: in the same way in which one corrects aberrations due to atmospheric turbulence by means of a deformable mirror, why not do the same to correct aberrations due to the tears and tear film? By capitalizing on its expertise in image processing, adapted to retina images by its researchers, ONERA is taking a leap forward to today by proposing two applications for ophthalmology. The first is laser surgery for diabetics. Although laser already exists, the point of impact remains poorly controlled. The instrument developed by ONERA will allow the surgeon to ensure optimum accuracy.

For neurodegenerative diseases involving vascular abnormalities, ONERA sees once again beyond the tip of its nose. The eyes are indeed a window to the brain: starting from this observation, the ONERA laboratory, a partner of Quinze-Vingts, now envisions a technology allowing the operation of the neurovascular network of the retina to be observed in real time on patients, and enabling the state of progress of pathologies affecting the brain to be deduced. In 2016, the video on the circulation of globules in one of the arteries close to the optic nerve, at the best level worldwide, made it possible to see more clearly.

1 The ONERA Écur’œil laboratory has been housed in the Quinze-Vingts hospital for 5 years.
2 Programme d’investissement d’avenir: Government investment program.

From astronomy to ophthalmology: ONERA sets its sights high
elsA and Cassiopée, strategic software for aerodynamics

The elsA software capitalizes on the know-how in aerodynamics and related disciplines – aeroelasticity, aerothermic, acoustic – as well as in numerical analysis and software engineering. The use of advanced models of turbulence and the prediction of the laminar/turbulent transition have advanced the simulation of flows, especially on aircraft. Fluid/structure coupling is also an area clearly progressing. In 2016, shape optimization took an important step, taking into account the flexibility of structures in the calculation of sensitivities.

So far, associated with elsA for pre-processing and mesh generation, Cassiopée now offers particularly effective solutions in terms of embedded post-processing of elsA calculations. These codes are deployed in the French aerospace industry, in particular at Airbus and Safran, for their research and design activities. Study and service companies, and research and academic organizations are also users (Cenaero, Cerfacs, DynFluid, and ISAE among others). They even participate in an extended validation of the elsA code.

The other codes are not left out…

CEDRE is ONERA’s numerical simulation platform for energy. Its applications are aerospace, space and defense. It is used for the benefit of industrialists (Safran, ASL and MBDA) and defense.

For ONERA’s research activities, CEDRE makes it easy to process geometrically complex configurations by taking into account all relevant technological details. In 2016, in order to take into account the critical phases of flows, in particular during the relative movement of two immersed objects, an “overlapping mesh” functionality started to be developed.

Developed by ONERA, it simulates the propagation of electrical signals and the problems of electromagnetic compatibility in complex cable bundles. It takes into account all installation conditions in any 3D environment: it can be coupled with 3D codes. Used by many partners, it is integrated into several commercial platforms. In 2016, significant changes were made to the code, in order to increase the volumetry of network models, and to significantly reduce computation time. Integrated into the CableSim pretreatment tool from ONERA’s partner AxesSim, these new capacities allow problems of industrial sizes to be addressed. It has been useful for the CORAC-GENOME eCentric-EMC project for Safran Electrical & Power and in the PEVE MOVEA2 for the electromagnetic maintenance of Dassault’s Rafale.

Numerical Simulation

The Z-set code, co-developed by ONERA and the École des Mines, has made a notable advance in the field of high-performance computing, integrating modern domain decomposition methods, allowing simulations using several thousand processors. The major innovation of this work, carried out in collaboration with LMT Cachan and CMAP, now allows simulations on highly heterogeneous media, such as the loaded elastomers that make up solid propellants. This allows for a better understanding of the materials on a microscopic scale and to feed simulations to the larger scales.

ONERA codes always on the right track

The ONERA software platforms allow, upstream, a product design to be tested, and in the industrial design phase allow it to be optimized. Several types of phenomena can be simulated: aerodynamics, aeroacoustics, materials, thermochemistry, electromagnetism, etc.

Their users are its own engineers. To advance in their research and for the projects entrusted to it by its industrial partners. The latter also make extensive use of the ONERA codes.

At the best international level, the ONERA codes are regularly awarded. Among others, in 2016, Intel selected ONERA to become an Intel PCC (Intel Parallel Computing Center). This label is associated with funding used to prepare industrial numerical simulation for the possibilities offered by new high performance architectures. In addition, ONERA and SME ANDHEO received awards for innovative aerothermal simulation in an airborne campaign for TOTAL Exploration Production at different sites, to detect and characterize hydrocarbons on the ground surface.

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ONERA at the heart of the international scientific community

ONERA is a major player in European and international research. This is a positioning that became strengthened in 2016.

ONERA CHAIRS THE CLORA PRESIDENCY

Between February 2016 and February 2017, Sylviane Pascal, Director of International Affairs and representative of ONERA in Brussels, assumed the presidency of CLORA1. In addition to the events that have made CLORA a success for 25 years (thematic days, high level meetings, etc.), the ONERA Presidency focused on making CLORA more visible, to send collective messages on major cross-cutting issues. For the first time, CLORA issued a paper position on the mid-term review of 2020, which was very well received by the European research community and its institutions. This was a highlight of the ONERA Presidency: the celebration of CLORA’s 25th anniversary in Brussels at the end of January 2017. Several distinguished guests took part, notably Carlos Moedas, European Commissioner for Research, Science and Innovation; Alain Beretz, Director-General for Research and Innovation of the Ministry for Higher Education and Research; as well as Christian Ehler, a German MEP who is very involved in the issues of h2020. Stéphane Andrieux, General Scientific Director of ONERA, underlined in his opening speech the essential role of CLORA in the construction of the European research policy.

Bruno Sainjon was elected President of EREA and took office on January 1, 2016. Two priorities are defined in his Presidency plan: to continue to look after the interests of EREA on collaborative research and strategic research infrastructures in European programs. This includes continued support for Future Sky, the Joint Research Initiative (JRI) of EREA for aviation. In addition, Bruno Sainjon is continuing his efforts to develop and promote a JRI-type initiative for aviation security. It is a question of “defending a strong, coordinated and effective research, in order to achieve ambitious objectives in terms of technological renewal, necessary for civil aviation in Europe in the coming decades”.

ONERA RECOGNIZED BY EREA

ONERA and its partners of the DLR, Airbus helicopters and DRAW (German Dutch Wind Tunnels) won the award for the best EREA paper of the year 2016. Tracing the ERATO / Blade 2005 / Blue Edge™ silent blade project, this publication is an opportunity to revisit a technological success made possible thanks to 25 years of coordinated research at the European level between States, research and industry.

In order to reduce aircraft noise, ONERA and NASA signed a four-year cooperation agreement covering four major research topics: absorbent materials, noise modeling around an airport platform (modeling of the source and propagation), the perception and the discomfort caused by the noise perceived by the local residents (auralisation and psychoacoustics), and the methods of signal processing for the identification of acoustic sources (position, sound levels). The challenge: the increase in competence of the two bodies, via a reinforced synergy on new themes. This agreement expands the NASA-ONERA partnership on noise, initiated in 2008, and is part of the framework cooperation agreement signed in 1991.

AEREOACoustics: intensification of research on noise and its perception

The combined will of ONERA and TsAGi to strengthen their ties was realized in 2016 by the signature of three technical agreements in Sochi (Russia) in October, by Bruno Sainjon and Sergey Chernyshhev, President of the TsAGi. They relate respectively to new configurations, aerodynamic modeling and meta-materials respectively. This last subject emerged in 2015, when the ONERA-TsAGi research award was created. This was the first edition of the award, which rewarded Cécile Davoine and Dimitri Bettegher of ONERA, as well as Yuri Dymnikov and Ivan Kondakov of TsAGi for their innovative research proposal on meta-materials. The first results presented at the last annual seminar are promising and will lead to a joint publication.

1 Club of Associated Research Organizations (Club des Organismes de Recherche Associés, representative of French Public Research in Brussels)
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.