

The essentials
2018
Annual Report

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Charles Champion

A WORD FROM THE CHAIRMAN OF THE BOARD OF DIRECTORS

The aeronautics and space adventure has only just begun.

There are many challenges – the energy transition, the conquest of space, etc., and the opportunities are expanding exponentially thanks to new technologies, the digital transformation and the development of Artificial Intelligence, to name a few examples.

But it is first and foremost a human adventure.

And that is ISAE-SUPAERO's mission – to prepare men and women to meet these exciting challenges.

We seek to attract the best and ISAE-SUPAERO's legitimate ambition is to be recognized as a world leader in this area.

This requires resources. Current and scheduled investments meet the needs of this ambition and new talents are joining the Institute.

This ambition can also be seen in the 2017-2021 Objectives and Performance Contract, whose progression is being monitored and supported by all ISAE-SUPAERO stakeholders. Along these lines, the charter signed in 2018 between the Institute, L'Amicale (Alumni Association) and the Foundation is strengthening the links between the Institute, students and Alumni.

The Excellence that is the Institute's ambition also involves being at the forefront in the area of research and we would notably like to welcome the launch of the Research Federation with ONERA and ENAC.

The Institute's Innovation can be seen in its support for many start-ups and in the many ambitious projects our students are involved

in, such as one of the key instruments for the Insight mission which landed on Mars on November 26th, 2018.

And ISAE-SUPAERO is also a human adventure, a talented team that is flexible and committed to serving the Institute and its students.

We can all be proud.

C.C.

A WORD FROM THE PRESIDENT

Fifty years ago, in 1968, SUPAERO came to Toulouse at the request of General de Gaulle's government to contribute to making the city the French capital of aeronautics and space. Equipped with a research center that is now the ONERA center of Toulouse, and in close proximity with ENAC, CNES, Université Paul Sabatier and laboratories such as LAAS-CNRS, the school was at the heart of a wonderful dynamic that turned Toulouse into the European capital of the aerospace sector and one of the most dynamic metropolises in France.

In order to make an ever more effective contribution to this ambition in a context of globalization in higher education and research, it was transformed in 2007 by merging with ENSICA to form ISAE-SUPAERO, which has since positioned itself as a world leader in higher education for aerospace engineering. The 2017–2021 Objectives and Performance Contract, which we signed with the Minister of Defense in December 2016, is designed to reassert our position as a world leader. Two years later, we have made good progress along the four lines it defined:

Developing our international attractiveness: starting with the most visible aspect, in 2017 we implemented our new communication strategy and our new visual identity (winning an award in London) with, for example, an excellent audience for our “brand film”! But we can also measure the results of actions undertaken several years ago, with strong growth in our foreign student recruitment, accounting for nearly 40% of our recruits in the summer of 2018. Likewise, nearly 40% of the teaching staff and researchers hired over the past two years have been foreigners.

Developing partnerships for international reference laboratories: with ONERA and ENAC, the Toulouse School of Aerospace Engineering (TSAE) university research school was set up this year, along with a research federation providing support and including most of the research forces at our three establishments in Toulouse. This has enabled us to attract even more post-graduates (over 70 recruits this year) and to promote more ambitious research projects, notably on the European level. Some of our research activities have enjoyed a great deal of publicity, such as our participation in the Insight mission to Mars – we will furthermore be coordinators for developing the next generation of planetary seismometers with the Pioneers project, financed by the

European Union's H2020 program.

Constantly developing our training offer to meet the changing needs of industries and students: with Thomas Pesquet, we awarded the last ENSICA and SUPAERO diplomas, since future graduating classes will now follow the single ISAE-SUPAERO program. We are still the fifth French engineering school in terms of student preferences after competitive exams, and we have seen our share of female students grow sharply, to nearly 25%. The Master in “Aerospace Engineering” in English, inaugurated in 2016, had a 40% increase in enrolment, welcoming 110 new recruits from around the world. At the start of 2019, we are offering two new MOOCs, also in English.

Influencing changes in higher education and French research: beyond the creation of the Toulouse School of Aerospace Engineering with ENAC and ONERA, mentioned above, we have also consolidated the ISAE Group this year, of which SUPMECA became the fifth member at the start of 2019.

We have also made progress on our third pillar, innovation, with the birth of the first spin-offs associated with our laboratories: U-Space (nanosatellites), Speeryt (communication protocol) and Hinfact (man-machine interface), and with the deployment of our first “InnovSpace” around our FabLab.

Lastly, with our Foundation and l'Amicale (Alumni Association), we have signed a tripartite charter aimed at giving new impetus to mobilizing our alumni and we are continuing to modernize our in-house processes at the Institute, this year notably with a new accounting and budget management tool.

Our Institute is thus on the move on all three of its feet – training, research and innovation – to assert its position as a world leader in higher education for aerospace engineering, and to continue to contribute to the success of the French and European aerospace sector, as well as to our students' success.

O.L.



Olivier Lesbre



Our promise for the future

At the heart of aerospace engineering's development since 1909, we give you the keys to invent the world of tomorrow.

Our mission: to educate the best engineers, leaders in the aerospace industry and in the world of tomorrow.

Our ambition: to assert ourselves as a world leader in higher education for aerospace engineering, relying on the 3 pillars of teaching, research and innovation.

Our vision: a wealth of talents, demanding and diverse formative tracks, commitment and passion are the engines of innovation in an increasingly complex world.

The Objectives and Performance Contract signed with the Ministry of the Armed Forces sets the course for 2017–2021

4 major objectives:

- / Develop the Institute's international attractiveness for the best students and professors from around the world;
- / Develop international reference laboratories in aerospace research in partnerships to promote the ISAE-SUPAERO brand;
- / Constantly develop initial training and continuing education to meet new needs among industry and students;
- / Be an active, influential institution in the changing landscape of higher education and research, nationally and internationally.

Highlights in 2018

/With ONERA and ENAC, the Toulouse School of Aerospace Engineering (TSAE) university research school was set up, along with a research federation including most of our teams in Toulouse

/40% growth in our recruitment of students for the "Aerospace Engineering" Master of Science in English, with 110 new arrivals

/Creation of the first spin-offs associated with the Institute's laboratories

/Implementation of SIFAC, the new accounting and budget management tool

A few examples reflecting the scope of the individual and collective investment at work every day for the Institute's development and reputation.

Human resources

total staff: **568**

number of professors
and research engineers: **106**

Student population **1,700**
students

Finances

subvention from the
French government:
€35.60 million

€61.10 million

total budget: including
€10.1 million in investments,
including **€2.9 million** in
investments for research.

In-depth participatory process review (RPAP)

In continuation of the work on simplifying and improving the financial and accounting processes carried out in 2016 and 2017, ISAE-SUPAERO has expanded this approach to the Human Resources, Infrastructure and Logistics, and Engineering Program processes. All our processes should have undertaken this exercise by the year 2021.



Founded on Excellence

Excellence with passion – that is our motto.

Since 1909, hand-in-hand with the aeronautics and space industry, excellence has been our heritage, our foundation and our ambition.

At the heart of our activities, our disciplines and our professions, we cultivate and instill this desire for perfection.

/ EDUCATION PROGRAMS

- / "Ingénieur ISAE-SUPAERO"
- / CNAM-ISAE engineering apprenticeship training program
- / Master of Science in Aerospace Engineering (in English)

Increasing feminization

+ **10%** in the Ingénieur program
between **23** and **26.5%**
depending on the program

More than **30**
programs

8 Certificates of Advanced Studies for professionals and a catalogue of continuing education programs offered by our affiliate, EUROSAE

14 Advanced Masters® in Aeronautics and Space and in Management (including 11 in English)

5 Research Masters:

- Energetics, thermodynamics
- Mechanical engineering
- Mathematics and applications
- Networks and telecommunications
- Sciences of the universe and space technologies

6 Doctoral schools:
Aeronautics-astronautics; Electrical Engineering, Electronics, Telecommunications; Mechanics, Energetics, Civil Engineering and Processes; Mathematics, Information Technologies and Telecommunication; Sciences of the Universe, the Environment and Space; Systems.

/ Programs “Ingénieur ISAE-SUPAERO”

Academic partnership: a double diploma agreement with Sciences Po Paris

At the start of the 2018 academic year, three students from Sciences Po and six engineering students from ISAE-SUPAERO joined this new double diploma program. The latter – who had validated the 2nd year of the engineering program – are currently following the Master 1 program at Sciences Po; they will then come back to complete their program at ISAE-SUPAERO.

The Sciences Po students, on the other hand, followed the 2nd and 3rd years of the engineering program after their Master 1 at the École des Affaires Internationales, the École du Management et de l’Innovation or the École Urbaine. At the end of these programs, the students receive the diploma from the Institut d’Études Politiques in Paris and the title of ISAE-SUPAERO engineer. They thus have double expertise that lets them look forward to a great career at public or private institutions in international and multicultural environments.

ISAE-SUPAERO and ESPCI Paris join forces to offer excellence

ISAE-SUPAERO and ESPCI Paris, two renowned engineering schools, signed an agreement in June 2018 for setting up a double diploma. This partnership seeks to diversify the profiles of the graduates to meet recruiters’ needs. Thanks to this cooperation, students will be able to take advantage of the complementarity of the expertise at the two institutions in terms of training and research at the crossroads of physics, chemistry, biology and aerospace engineering. The first beneficiaries of this agreement joined the program in September 2018.



Owl course: a game for a better understanding of the program!

In recent years, the possibilities for customizing programs have multiplied in response to the needs of recruiters and students alike. Helping students to make consistent choices had become a necessity. So the PACC (Parcours d’Aide à la Construction du Coursus – Assistance Path for Building a Program) was developed to provide 1st-year students with tools and an environment that would let them define the program that corresponds to their needs. Among the activities on offer, we can mention the MBTI® test for knowing oneself better and understanding oneself better, and a workshop based on a collaborative board game in response to a career goal. After gaining an understanding of the paths that are open to them, they have a variety of opportunities to meet academic contacts, 3rd-year students and alumni in order to gain in maturity and refine their project with peace of mind. One must play to be serious, as Aristotle used to say...

318
graduates
in 2018

including **83**
international students



Training for innovation: our students take part in “48 heures pour faire vivre des idées®” (48 hours to bring ideas to life)

As part of the Project for Innovation and Creativity (PIC), 1st year students took part in a collaborative challenge, “48 heures pour faire vivre des idées®” (48 hours to bring ideas to life) which took place at INSA Toulouse from November 29th to December 1st, 2018. More than 750 students from the engineering and design programs and from business schools were divided into multidisciplinary groups of 10 participants each, pooling their skills for three days to bring forward new creative concepts on subjects proposed by businesses – an excellent opportunity to learn to work together in a team with different profiles, to share knowledge and methodologies and to convince a jury. Our students will be able to develop this creative approach in implementing their PIC.

/ Programs Engineering apprenticeship program

In September 2018, 36 apprentices joined the apprenticeship course sponsored by CNAM in partnership with ISAE-SUPAERO. 75% of them held a DUT (University Technical Degree) in Mechanical Engineering and Production, Physical Measurements or Electrical Engineering and Industrial Data Processing. The other apprentices held BTS, CPGE or Licence degrees. 63% were apprentices at companies belonging to the Airbus and Safran groups.

Our students’ civic commitment is recognized

In 2018, the Certificat Diversité Engagement Citoyenneté (Diversity, Commitment and Citizenship Certificate) was set up. Issued by the Institute, it promotes our citizen-students’ experiences working toward openness and diversity.

After an admissions phase and producing a report on their experiences and their impact on their personal growth, the candidates speak before a panel of academic, industrial and institutional experts. Conferences and roundtables contribute to their approach and reflections. Eleven students received the Certificate in 2018 for their humanistic understanding of the world with all its diversity and all its wealth. They were thus able to step back and compare their vision of their role in society to that of committed engineers – another opportunity to look forward to future civic participation.

Merit scholarships dedicated to international mobility for students in the Engineering program

/ 2 engineering students admitted to the MSc in Aeronautics and Astronautics at Stanford University, USA, and to the MSc in Aerospace Engineering at the University of Michigan in Ann Arbor, USA, awardees of the **Jean Walter-Zellidja Scholarship** from the Académie Française

/ 1 engineering student admitted to the MSc at Stanford University and awardee of the **Fulbright Student and Monahan Foundation**.

54

had a double competence validated by a second diploma in management, business administration, economics or entrepreneurship:

- DESIA Certificate
- Toulouse School of Management
- HEC
- Toulouse School of Economics
- Imperial College Business School, Master in ITE at Polytechnique

35

graduates took a Research Master’s along with their 3rd year

On average, their experience abroad lasts **8** months

40

students from the Ecole Polytechnique chose to complete their engineering training at ISAE-SUPAERO.

/ Programs

Aerospace Engineering Masters

Number of applications are up sharply

The Master of Science in Aerospace Engineering welcomed 109 students for its third session. The number of high-quality applications jumped in 2018, letting us increase the number of students admitted while preserving the selectivity of the admission process.

73

Master of Science in Aerospace Engineering graduates

New in 2018

- In May 2018, the government of South Australia granted two “up & coming space entrepreneurs” scholarships to students accepted for the MAE.

- In June, a team of MAE students received the Airbus Defense & Space Award for their Greenvest project (ActInSpace hackathon). It includes a €100,000 voucher for satellite data for the creation of a start-up. The goal is to apply artificial intelligence to satellite data in order to optimize the effectiveness and installation of renewable energy solutions depending on the territory in question.

/ Programs

Advanced Master®

New in 2018

The MS Space Applications and Services (SPAPS) is mentioned as one of the best examples of University/Industry cooperation internationally in the AIRBUS White Book, “The Engineer of the Future”.

235

students were awarded with an Advanced Master®

MSc in Engineering - Aeronautics in Malaysia

Since 2014, ISAE-SUPAERO has participated in the creation of an MSc in Engineering-Aeronautics (MSEA) at the National Defense University of Malaysia, with support from Airbus Helicopters for setting up a combined master. After their MSEA studies, the best students, selected jointly by the NDUM and ISAE-SUPAERO, can be admitted into the 2nd year of the MAE Master in Toulouse and will obtain the two diplomas at the end of their studies. The MSAE Master opened at NDUM in March 2018 and welcomed its first class of 11 students. Two of the best students should join the MAE Master in September 2019.



Partnerships and scholarship programs



Partnerships with the institutions that provide financial support to the Master of Science and Advanced Masters® students are essential assets for our attractiveness, notably abroad.

3 merit scholarships from the ISAE-SUPAERO Foundation for welcoming international Master students were granted to 1 Italian student, 1 Canadian student and 1 Iranian student.

3 DGA scholarships: 1 South Korean student in MS Embedded Systems (EMS) and 2 Indian students in MS Aeronautical Maintenance and Support (AMS) and MS Aeronautical Engineering - TAS Aero received financing this year from the DGA for all or part of their studies.

6 MBDA scholarships were granted, 4 of them to Indian students and 2 to Indonesian students in MAE 1*.

2 CEDAR scholarships: CEDAR scholarships are granted under the CEDAR Chair (Airbus). This year they were granted to 1 Italian student and 1 Russian student in MAE 1.

3 GIFAS scholarships: GIFAS granted these scholarships to MAE 1 students from Thailand, Burkina Faso and Spain.

1 ARISE scholarship: The ARISE scholarship is granted under the ARISE Chair (Thalès). This year it was granted to 1 Portuguese student in MAE 1.

4 TSAE scholarships: TSAE scholarships are granted under the new EUR born of the cooperation between ISAE-SUPAERO, ENAC and ONERA. 4 scholarships were granted to Portuguese, Romanian, Argentinian and Indonesian students in MAE 1 in a PhD track.



* MAE 1: 1st year of the Master of Science in Aerospace Engineering

In all
22
merit scholarships were granted,
7 of them to female students

The Occitanie Region's Regional Professional Training Program (PRFP):

This year, **3** job seekers in retraining received financing for various Advanced Masters® (MS AMS and MS SPAPS).

/ Programs

Continuing education

We are consolidating our continuing education activities and now propose 8 institution certificates and 28 short modules under the ISAE-SUPAERO Executive Education brand, rounding out the offer of 270 internships offered by our subsidiary, EUROSAE. The first dedicated catalogue was published in January 2019. Since the summer of 2018, we have been a co-coordinator of the continuing education working group at CGE, with ESSEC.



European Consortium for Advanced Training in Aerospace

The closing ceremony of the ECATA international program took place on Thursday, April 19th, 2018, at TU DELFT. The 10 weeks of training were held in Madrid (ETSIAE), Munich (TUM), and then Delft, for a graduating class of 23 delegates, managers and high potentials identified by Dassault, Airbus, MTU, BAE Systems, SAAB, Liebherr Aerospace, Leonardo and Safran



ISAE-SUPAERO kept its “vocational training conformity” certificate after its oversight audit in July 2018.

200
PhD students

6
doctoral
schools

/ Programs Doctoral programs

A member of University of Toulouse Midi-Pyrénées and accredited by six doctoral schools, ISAE-SUPAERO welcomes PhD students at six ISAE-ONERA and Clément Ader Institute doctoral host teams. They cover a wide range of scientific disciplines related to the aeronautics and space fields: aerodynamics and propulsion, structures and materials, embedded systems, networks and telecommunications, systems command and control, human factors, electronics, and signals.



Rise in the number of enrollments and diversification of funding sources

For the first time in 2018-2019, the number of first doctoral enrollments at ISAE-SUPAERO rose to over seventy, 36% of them foreign students. Funding sources also diversified. The first theses financed by EUR-TSAE (two of them on international jointly-supervised doctorates with Australia and Canada) were presented, as well as the first theses under the ONERA-ISAE-ENAC Federation. These new arrangements are in addition to the traditional institutional partnerships with ONERA, CNES, CEA, the Occitanie Region, and partnerships with industrials who continue to place their trust in ISAE-SUPAERO, for example through the thirteen CIFRE agreements signed.



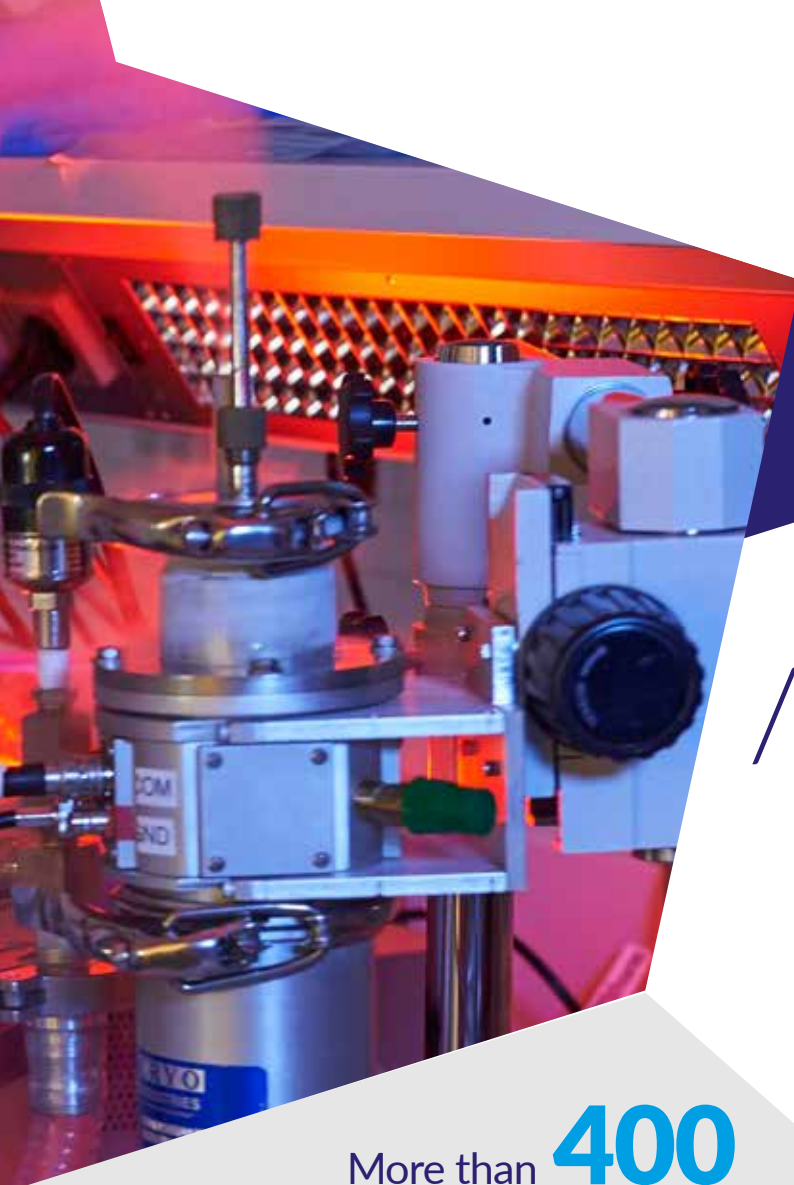
A string of awards for doctoral students

The excellence of the doctoral work carried out at ISAE-SUPAERO has been recognized by many awards, including the Outstanding Student Paper Award at the NSREC conference, which went to Clementine Durnez, a Best Presentation Award for Thibaut Lunet at the 7th Workshop on Parallel-in-Time methods, the ONERA doctoral student award given to Florian Monteghetti and, lastly, the GEET thesis prize for Vincent Laquerbe. Furthermore, as it does every year, the ISAE-SUPAERO Foundation gave out six prizes to the best theses defended at ISAE-SUPAERO, whose recipients were A. Brunet (physics and space), M. Bouyges (space propulsion), C. Durnez (electronics), M. Lasserre (radar), B. Le Bihan (mathematics and space) and A. Orotolan (aerodynamics).

National Day of the Communauté Française des Docteurs

In July 2018, ISAE-SUPAERO hosted the National Day of the Communauté Française des Docteurs, organized by the Association Nationale des Docteurs (Andès) for the first time in Toulouse. The day brought together 140 participants for highly interesting debates on the subject of geographical, sectorial or disciplinary mobility for PhDs.





/ RESEARCH

More than **400**
researchers on campus,
including ONERA

2

research units
evaluated by
HCERES

1

University Research
School supported by
the Institute

23

patents and invention
disclosures

101

internationally
peer-reviewed articles

/ Research

Our science policy

The scientific projects and topics at ISAE-SUPAERO are constantly being energized, improved and renewed by the commitment and excellence of the scientific staff. Through its scientific policy, ISAE-SUPAERO balances its goals for publications (1), activities (2) and resourcing (3):

- 1) – Jointly improving the impact of its publications in the best scientific revues and targeting some of them for better international scientific recognition in Aerospace Engineering ;
- 2) – Encouraging discovery, innovation and disciplinary cross-pollination to face economic, societal and environmental challenges, using cross-cutting activities organized along five strategic lines;
- 3) – Developing effective, sustainable resourcing for research to find flexibility, robustness and performance.

Six training and research departments

These ensure training actions and the training-research link and develop in-depth disciplinary and interdisciplinary scientific topics at the laboratories.

- / Aerodynamics, Energetics and Propulsion (DAEP)
- / Aerospace Vehicle Design and Control (DCAS)
- / Mechanics of Structures and Materials (DMSM)
- / Complex System Engineering (DISC)
- / Electronics, Optronics and Signal Processing (DEOS)
- / Languages, Arts, Culture and Society (LACS).

Creation of the “Aerospace Systems of the Future” Research Federation

In May 2018, ONERA, ENAC and ISAE-SUPAERO launched a joint Research Federation in the field of “design, certification and operations of future’s space systems” to facilitate exchanges and scientific cooperation which have existed between the three institutions for several years.

The product of the shared desire of ONERA and ISAE-SUPAERO to work more closely together, the Federation is an extension of the scientific coordination actions that we carry out to strengthen Aerospace Engineering research at the Toulouse site: creation of GIS Microdrones, launch of the Centre Spatial Universitaire Toulousain, success of the University Research School, the Toulouse School of Aerospace Engineering (TSAE).

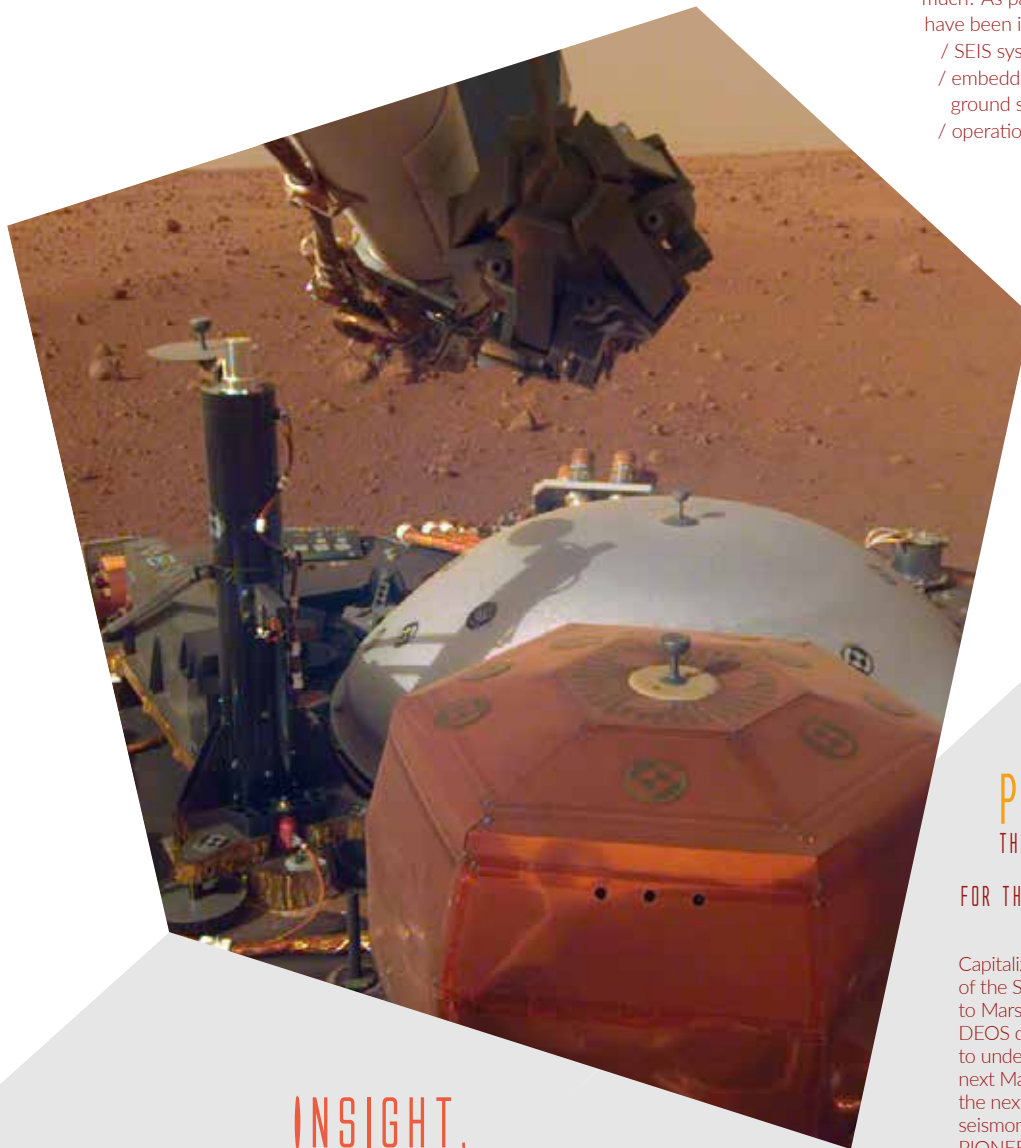
= INSIGHT =

A SUCCESS FOR OUR SPACE ACTIVITIES

The major success of the year 2018 for our space activities was unquestionably our contribution to the InSight mission, which is the twelfth mission in NASA's Discovery program. It carried the SEIS instrument, an ultrasensitive seismometer designed at the Institut de Physique du Globe de Paris (IPGP) in collaboration with ISAE-SUPAERO and many other international partners and carried out under CNES's oversight.

The goal of the InSight mission is to take a "sonogram" of the inside of Mars to answer the question: why did the fates of Earth and Mars diverge so much? As part of the InSight consortium, we have been involved in:

- / SEIS system engineering
- / embedded software and the scientific ground segment
- / operations for the Mars probe



INSIGHT, AN EDUCATIONAL SPACE MISSION

On 26 November 2018, the InSight probe landed on Mars right before the amazed eyes of 450 young people invited by our diversity program, OSE l'ISAE-SUPAERO, to watch the live broadcast of this historic event. These middle and high school students got to attend educational presentations, do seismic experiments and talk with our students. A custom-made program applauded by Mesdames the Academic Rector of Toulouse and the Sub-Prefect of the Haute-Garonne department, who were in attendance.

PIONEERS, THE NEW DEVELOPMENT PROJECT FOR THE UPCOMING GENERATIONS OF SEISMOMETERS

Capitalizing on its contribution of the SEIS seismometer sent to Mars, the SSPA team at the DEOS department will be able to undertake another project next March in view of developing the next generation of planetary seismometers: PIONEERS (Planetary Instruments based on Optical technologies for an iNnovative European Exploration using Rotational Seismology). Continued on p.19.

/ Research New equipment

BEAM, an additive manufacturing workshop

In response to the development of digital technologies for design and production at the factory of the future X.O, ISAE-SUPAERO has sought to equip itself with the workshop of the future specifically oriented toward titanium additive manufacturing and conditions of weightlessness. The purchase, in April 2018, of a machine for additive manufacturing (AM) using metal powder deposits, compatible with the use of titanium is the first step. This equipment supplements local resources (IRT, CIRIMAT) and the equipment at École Polytechnique, and paves the way for essential research for the Clément Ader Institute (ICA), such as the development of dedicated materials for AM, AM design combined with virtual digital design, and topological optimization.

Successful calls for projects

ANR PER4MANCE Project

PER4MANCE is a project dealing with scheduling and flexible distribution of work between operators on aeronautical assembly lines: a systemic approach to managing ergonomic and economic risks.

Put forward by an ISAE-SUPAERO researcher, it obtained financing from the France's Agence Nationale de la Recherche (ANR - National Research Agency). It is coordinated by ISAE-SUPAERO for 4 years in a partnership with four laboratories and two industrials - LAAS, IRIT, Institut National Universitaire Champollion, Airbus, Dassault Aviation and the Universidad Politécnica de Madrid. Acceptance of the project submitted is indicative of the strategic and scientific importance of the subject and the quality of the consortium chosen. It demonstrates both the quality of the research carried out on the subject at the Institute and the relevance of the sponsor for the subject.

PANDO - High Performance Computing

PANDO is dedicated to all our research departments, with applications in fluid mechanics, structural mechanics, electromagnetism and artificial intelligence. This acquisition enables the Institute to preserve a high performance computing (HPC) service offer and to take its rightful place as the first market for HPC service offers operating through calls for projects, whether regional (CALMIP), national (GENCI) or Europe-wide (PRACE). PANDO's computing power is 20 times greater than the previous machine and will be able to perform calculations whose applied character is not privileged in outside resources.



Pando,
the scientific
computer

GENCI, PRACE: intensive computing resources are now available

As part of the European SCONE project, our Department of Aerodynamics, Energetics and Propulsion (DAEP) made a request to the GENCI and PRACE authorities for several million hours of digital simulations to take advantage of their very high-level HPC machines. One of the expert opinions assessing the allocation of these computing hours stated: "The project's thematic and methodological consistency suggests good team dynamics with advanced expertise in terms of both physical analysis and the mastery of simulation tools, with integration into international research programs. The computing work performed is impressive and often without equivalent. For all these reasons, the committee recommends total allocation." The digital approach is indispensable in fluid mechanics today, notably due to its complementarity with the theoretical approaches to modelling and experimentation.

Increased momentum at the Centre Spatial Universitaire de Toulouse

Founded in 2016 at ISAE-SUPAERO's initiative and directed by Professor Bénédicte Escudier, CSUT gained significant momentum in 2018, notably with the arrival of a technical director and "professional" engineers.

A true vehicle for training, CSUT puts students and engineers in real-life situations: they work on scientific missions proposed by the Center's members. Since the design of the EntrySat and Nimph nanosatellites, the "Cubesat 3U" and "Cubesat 12U" lines have emerged in cooperation with ENSTA Bretagne, ONERA, CSU Grenoble and IRAP. Beyond these projects, CSUT is also contributing to the NANOSTAR project, financed by European "Interreg Sudoe" funds.

/ Research Activité Spatiale

PIONEERS, the new development project for the next generations of seismometers

Capitalizing on its contribution of the SEIS seismometer sent to Mars, the SSPA team at the DEOS department will be able to undertake another project next March in view of developing the next generation of planetary seismometers: PIONEERS (Planetary Instruments based on Optical technologies for an iNnovative European Exploration using Rotational Seismology). Sponsored by ISAE-SUPAERO and a European consortium of research laboratories (IPGP, ETHZ, ORB and LMU) and industrials, this project was selected for the Horizon 2020 program, the largest European research and innovation program. The PIONEERS team is made up of key members of the European consortium that supplied the SEIS, including the Institut de Physique du Globe de Paris. Aiming at a technological breakthrough, the next generation of sensors will be based on optical interferometry technologies developed by the industrial partner, iXBlue. With PIONEERS' innovations, Europe will be able to stay one step ahead in its technological advances.



10th European Cubesat Symposium

This tenth European Cubesat Symposium was organized by CSUT, the Toulouse University Space Center. Over 200 participants, academics, institutions and industries from some twenty countries took part in several sessions on the following topics: missions, instruments, technologies, launchers and deployment systems, international cooperation, etc.



“MOSIM 2018” at ISAE-SUPAERO: the rise of connected systems

At the end of June 2018, the 12th MOSIM conference (Modelling, Optimization and SIMulation of systems) was held at ISAE-SUPAERO. Its organizing committee was co-chaired by ISAE-SUPAERO and the École des Mines Albi, and the scientific committee was co-chaired by ENI Tarbes and the Director of the major artificial intelligence and Big Data program, IVADO, at Polytechnique Montréal. This edition offered a discussion and debate area, with the guiding theme being “the rise of connected systems in industry and services”. MOSIM 2018 brought 15 special sessions, 104 submissions and 91 contributions accepted for a total of 358 authors from around the world.

Flight authorization for the EntrySat nanosatellite

The EntrySat mission, which we designed and produced with support from the CNES and in cooperation with ONERA and CSUT, is our first CubeSat and the sixth French nanosatellite. After years of collaborative efforts, the flight authorization for EntrySat was obtained in 2018. It is designed as a low-cost demonstrator for the reentry of space debris, the goal being to reproduce not only its trajectory, but also the breakdown of its constituent materials. The EntrySat satellite will be launched in April 2019 on a Cygnus vehicle in route for the ISS, then placed in orbit by the station's robotic arm.

A year rich in events

Joël Serra, PhD at the Institute, receives the Fondation Lopez-Loreta prize

Since 2018, the Fondation Jean-Jacques et Felicia Lopez-Loreto has been encouraging students at four European institutions of Higher Education (ETHZ, EPFL, I'X and ISAE-SUPAERO) to carry out highly promising, innovative entrepreneurial and/or academic research projects.

For this first year, Joël Serra, a SUPAERO engineer and PhD, received this prize for the VIRTUOSE project (VIRTUAl testing of aerOnautical compoSite structurEs), whose main objective is to simulate the mechanisms behind damage to composite materials so as to be able to better predict the mechanical strength of structures.

Scientific publications: toward a new strategy

We have launched in-depth work on our scientific production, an area in which the number of publications constitutes an indicator in the Objectives and Performance Contract (COP). We have made constant progress. But the main target remains our Institute's visibility, notably in the international rankings of institutions of higher education and research. In order to adopt the best strategy to promote our scientific publications, the Institute has called upon SIRIS Academic, a consulting and research firm. Their various studies have helped us to undertake in-house bibliometric work. Discussion sessions have been organized with our researchers so that we can share a common publication strategy. ISAE-SUPAERO's goal

is now to make progress and, over time, to reach a good place in the international thematic rankings for Aerospace Engineering, such as the Shanghai ranking on this subject.

Results

Publications in international peer-reviewed journals play a major role in assessing our scientific research production, and this affects the different rankings of teaching and research institutions. For ISAE-SUPAERO, several challenges need to be met – total number and quality of our publications, overall number of publications on the topic of Aerospace Engineering in journals defined as being the best in this field.



101
Publications



The world: our horizon

Here and everywhere around the world, our activities lead us to enter into interactions with women and men, professionals, researchers, professors, students and partners. This desire to go further, to expand our possibilities and to create new connections is built into our DNA. We grow through these exchanges and this sharing.

New international agreements to go further

In 2018, we signed many academic cooperation agreements with prestigious foreign universities: University of New South Wales (UNSW) in Sydney, University of Toronto, the Korea Advanced Institute of Science and Technology (KAIST) in South Korea, Tsinghua University in China and Moscow State University (MSU) in Russia.

Double diploma agreements were renewed: Royal Institute of Technology (KTH) in Stockholm, Sweden, École Polytechnique Fédérale de Lausanne (EPFL) in Switzerland, Politecnico di Milano in Italy, opening up new topics such as Management Engineering, for example.

28
partner countries

96
partner
foreign
universities

100
academic cooperation
agreements including
33 degree or double
diploma programs

31%
of graduates come
from abroad





/International Openness is at the heart of our events

Special programs

/ Opening of the “Spring Semester in Aeronautical Engineering”

A new program has been set up to welcome foreign university students on the Bachelor’s Degree level. Taught in English, the “Spring Semester in Aeronautical Engineering” is a complete semester of studies in the aeronautics field. The first session was a success, as 6 foreign students (KTH Stockholm, University of Southampton and National University of Singapore) were welcomed to our Institute.

/ Second annual “Space Summer Program”

In order to encourage the international reputation of European expertise in the space field, the ISAE Group organized this summer school to provide solid training on the subject “Space from the European point of view”. Based on the fields of expertise at each school in the group, a rich program was organized, with theoretical and practical courses, conferences and industrial visits in France, notably to Thales Alenia Space.

/ ENAC, ISAE-ENSMA and ISAE-SUPAERO working together for the “2018 GEA Aviation Summer Program”

This 6-week program for undergraduate students from American universities that are partners with ENAC, ISAE-ENSMA and ISAE-SUPAERO provides an overall understanding of aeronautics, with courses, conferences, and industrial and cultural visits.

Missions abroad

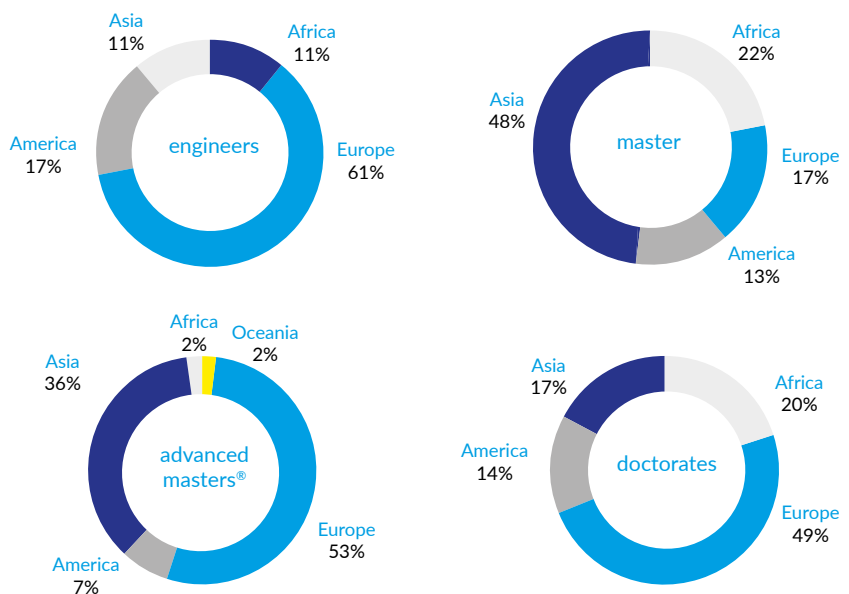
All year long, ISAE-SUPAERO meets with foreign universities, thus cultivating a desire for openness:

- / Participation in the Franco-Indian aeronautics university forum in Bangalore and visits to the partner Indian universities, IISc Bangalore and IIT Madras.
- / Development of cooperation with Australian universities (University of Sydney, University of Adelaide, RMIT Melbourne) to bring us closer together in the space sector as academic partners.
- / Visits to Moroccan institutions, including the Mohammadia School of Engineering in Morocco.
- / A working visit to the American universities of Stanford, Berkeley and Caltech.

Delegations at the Institute: strengthening our cooperation in teaching and research

With a view to developing new partnerships and strengthening our international cooperation in teaching and research, we welcomed 28 foreign delegations from 16 countries: Canada, Singapore, Switzerland, Belgium,, Japan, Australia, United States, India, Brazil, China, Colombia, Thailand, Russia, Morocco and Sweden.

Origin of foreign students, distribution by programs in 2017-2018



250
companies
support our growth

More than
30
formative
partnerships
signed with small
and medium-sized
firms and major

11
company teaching
and research chairs

2018 apprenticeship tax:
230 donors
€493,000
collected (+3%/2017)

half of our
1,800
lecturers come from high-tech
companies and academia



11 Teaching and Research Chairs: connections with the aerospace industry and innovation

- / AIRBUS Chair in Eco-Design of Aircraft (CEDAR)
- / MBDA-ISAE excellence program for India and Indonesia
- / AXA Chair – Neuro-ergonomics for aircraft safety
- / Nuclétudes Chair – Impact of radiating environments on space systems design
- / SAFRAN Chair – Aero Engine Innovative Studies (AEGIS)
- / TAS Chair (jointly with ITA in Brazil)
– Teaching on small satellite platforms
- / THALES Chair – Architecture and Engineering for Embedded Systems (ARISE)
- / DASSAULT Chair – Aircraft System Architecture (CASAC)
- / TAS partnership – CMOS image sensors applied to space (SaCLab)
- / Airbus Defence & Space and ArianeGroup Chair – Advanced Spatial Concepts
- / GIFAS Chair – Support for the ISAE Group

Wide diversification in cooperation

In 2018, ISAE-SUPAERO once again expanded the number of its partnerships in its core sector – Aerospace. New partners now include LATÉCOËRE, ARIANE GROUP and ASSYSTEM.

It should be pointed out that this year also brought the renewal of the partnership with Safran. Real sectorial diversification in partnerships came about, driven by industrial demand as well as by the students, who want to explore new sectors of activity. There were therefore closer contacts with the transportation and digital technologies sectors through the development of cooperation with such industrials as SIEMENS, CONTINENTAL, SOPRA STERIA, ATOS and AIR LIQUIDE, as well as with consulting firms in many sectors, such as PWC and CyLAD Consulting. ISAE-SUPAERO also signed partnership agreements with innovative small businesses such as Star Engineering, mecanoID and Sysnav, which are smaller companies in the “start-up” spirit, a status that is highly prized by students.

Renewal of the GIFAS Chair

In 2018, GIFAS once again confirmed its support for the ISAE Group’s development in a sponsorship agreement between GIFAS, the ISAE Group and the ISAE-SUPAERO Foundation. The Chair’s stated purpose is to provide support to developing high-level academic and vocational teaching in the field of aerospace systems.

/Business relations A pillar of the school’s strategy

We place the development of business relations at the heart of our concerns and our strategy. Historically, we have forged very strong, solid relations with industrials in the aeronautics and space sector, but also with other business sectors such as transportation, energy, digital technologies, consulting, finance, etc.

Meeting between sponsors and scholarship recipients

The annual meeting between the school’s major sponsor companies and the students receiving support under the sponsorship chairs has grown in scope. Organized by the ISAE-SUPAERO Foundation, this year it brought together some forty student awardees from five continents and representatives from such companies as Thales Avionics, with the ARISE Chair (Architecture and Engineering for Embedded Systems), Airbus with the CEDAR Chair (Chair for Eco Design of Aircraft), MBDA with the Excellence Program for India and Indonesia Chair and GIFAS, which provides support for the ISAE Group’s development.

Partners Morning

ISAE-SUPAERO organized 2 “Partners Morning” meetings in the form of creative workshops in June and December 2018. The purpose of these meetings is to encourage connections with companies and to bring out new ideas for cooperation.



/ Business Relations

A pillar of the school's strategy

The year in Workshops

The third workshop organized with the players in the CASAC Chair was marked by several demonstrations this year, including multi-drones flights and the use of the FETA assistant with the PRE flight simulator. The same day, on the Airbus premises, research professors, post-graduates and students were mobilized to present their work on the flying wing called the Blended Wing Body (BWB) and the distributed propeller aircraft.

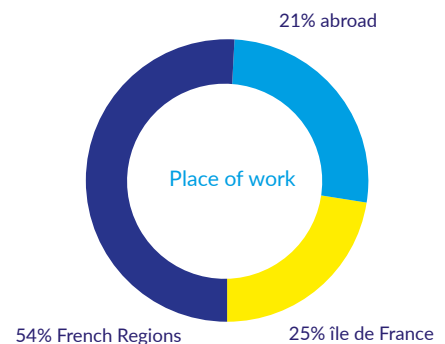
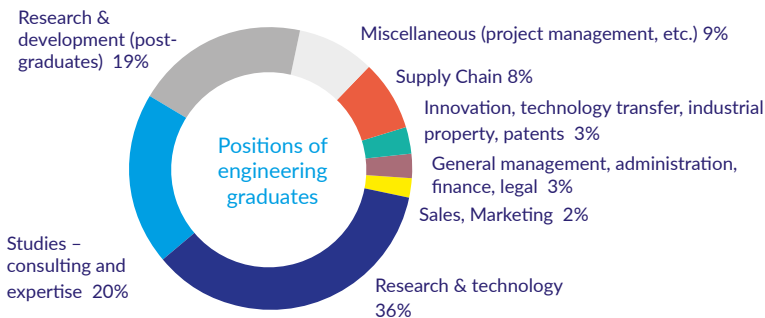
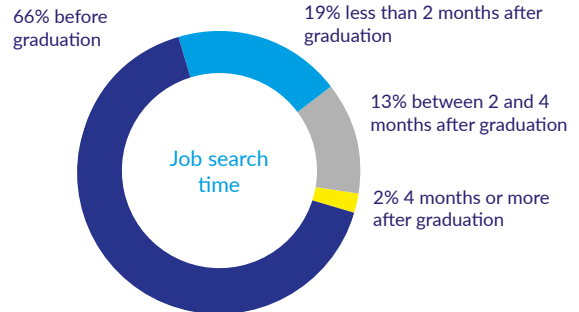
The first Workshop organized with the AEGIS Chair brought together more than 40 people, including 17 SAFRAN specialists, for an interdisciplinary meeting organized around 8 thematic workshops proposed by pairs of specialists in fields involved in propulsion systems.

Junior Enterprise "SUPAERO Junior Conseil"

Putting the engineering education of tomorrow into practice for today's companies – that is the challenge taken up by SUPAERO Junior Conseil, the first French aerospace Junior Enterprise, with 13 study agreements signed for €60,000 in sales in 2018. This year, alongside Airbus, Thalès, Latécoère, Dassault Aviation, Continental and Assytem Technologies, and with partners such as the SII Group and 3AF, SUPAERO Junior Conseil opened up to new aeronautical and digital challenges – a prototyping study on an autonomous solar drone for a start-up, image processing for Bouygues Construction, visits to the France Air Expo and Toulouse Space Show, etc.

The Career Center: a springboard helping students enter the workforce

The Career Center's mission is to accompany students from all training programs entering the workforce by creating bridges with businesses. Nearly 600 students came looking for advice in individual interviews or collective workshops in 2018. More than 2,000 job and internship offers were posted on the Institute's job board. The Career Center also organizes more than 30 events on campus or at industrial sites jointly with partner companies seeking to improve their employer brand. industriels.



Main recruiters: AIRBUS / SAFRAN / ALTRAN / MBDA / THALES / ARIANE GROUP / AKKA / CAPGEMINI / DASSAULT

Survey on 1st jobs in the 2017 class of engineering graduates – ISAE-SUPAERO Career Center

The ISAE Group

5 grandes écoles

ISAE-SUPAERO (Toulouse)
ISAE-ENSMA (Poitiers)
SUPMECA (Saint-Ouen)
ESTACA (Saint-Quentin-en-Yvelines et Laval)
École de l'Air (Salon-de-Provence)

6,000
students

1,600
graduates each
year

4,500
engineering
students

160
partner universities
(in 140 countries on
5 continents)

A network
of **41,500**
alumni



The ISAE Group brings together 5 Grandes Écoles in the aeronautics and space sector. Bringing together, under one umbrella, all of France's Grandes Écoles in aeronautical and space engineering to better meet the needs of the industrial sector and of students – that is the vocation of the ISAE Group, created in 2011.

The schools in the Group share the common values of excellence, openness and innovation. Their ambition is to train multidisciplinary engineers with varied profiles who can mobilize and coordinate all the technical and managerial skills that the aerospace industry will need to deal with major geostrategic, technological, ecological and socioeconomic challenges. In 2018, the ISAE Group gained a new member with the arrival of Supméca (Institut Supérieur de Mécanique de Paris), based in Saint-Ouen.

ISAE Group dynamics

Development supported by GIFAS

For five years now, GIFAS (Groupement des Industries Françaises Aéronautiques et Spatiales – French Aeronautics and Space Industry Group) has provided substantial financial support to the ISAE Group's development, reputation and diversity. In the field of training in particular, joint discussions with GIFAS were undertaken in 2018 on the subjects of apprenticeship and continuing education, two sectors that have undergone major legislative and regulatory changes.

Strategic reflections at 5 commissions:

- / Training
- / Research
- / Digital Learning (created in 2018)
- / International (created in 2018)
- / Promotion-image

Concrete actions and projects carried out in 2018

- / Continued work on EUROGLIDER, the first electric propulsion glider promoted by AEDEVV and designed with students from the Group in partnership with Dassault-Aviation;
- / Organization of a space seminar at the École de l'Air on the following topics: launch vehicles, space surveillance, the future and challenges of military space programs, and the uses and challenges of imaging.
- / Participation by 300 students in Mobility Week, organized by the different schools;
- / Organization of a "Space Summer Program" for American students;
- / Launch of an electric propulsion drone using solar energy and a fuel cell.

ISAE-SUPAERO-ENSICA Alumni Association



more than
22,700
graduates

12%
of alumni are abroad:
450 in North America
1,240 in Europe
275 in Asia

4 commissions :

- / Relations with the School and Professional Organizations,
- / Publications & Social Media,
- / Engineering Professions,
- / Community Coordination.

The Alumni network in action:

- / regional chapters, consulates abroad, company correspondents and class delegates;
- / highlights: participation in welcoming new engineering students, award ceremonies at "talent night", publication of the alumni directory, general meeting in June;
- / ISAEde, quarterly information bulletin;
- / cocktails, dinners;
- / more than 2,500 job offers;
- / afterwork events and career interviews;
- / travel;
- / an active presence on social media, notably Facebook and LinkedIn.

5 clubs :

- / ISAE Executive Club,
- / History & Memory Club,
- / ISAE Alumni Entrepreneurship Club,
- / ISAE-SUPAERO Women's Club,
- / Culture & Travel Club.

The Alumni Association works alongside ISAE-SUPAERO:

- / at official bodies, the board of directors, training and research council, and juries;
 - / promoting engineering training among students at scientific preparatory schools and I'X students;
 - / with the engineering students: participation in the back-to-school chains, "afterwork" welcome events for new students, honor loans granted to needy students, organization of a "diploma itinerary" day and theme dinners with alumni, participation in the graduation ceremony, graduating class sponsorships.
- The Alumni Association is a partner of the ISAE-SUPAERO Foundation and is one of its 4 founding members, with:
- / a representative on the board of directors, who is the general secretary;
 - / the organization of roadshows at companies, in collaboration with ISAE-SUPAERO.

The ISAE-SUPAERO Foundation



Fondation ISAE - SUPAERO

Reconnue d'utilité publique

The ISAE-SUPAERO Foundation is 10 years old!

Recognized as a public interest organization in 2008, the Foundation works to develop ISAE-SUPAERO's worldwide reputation by speeding up innovative, sustainable projects through donations collected from individual sponsors (alumni, parents of students, students and aerospace enthusiasts) and from companies.

The generosity of private individuals mainly goes to projects by students and research professors in the following forms:

- / merit scholarships for student mobility;
- / support for exchanges for research;
- / support for extracurricular projects;
- / support for entrepreneurial projects;
- / assistance for participating in or organizing conferences;
- / thesis awards



€221,000 raised from private individuals and
€3 M from companies in 2018.

Final stretch for the first 2011-2018 Fund Raising Campaign

En In 2011, the Foundation launched its first campaign "Give wings to their passion" for financing 5 main areas:

- / research and teaching,
- / entrepreneurship,
- / ISAE-SUPAERO's international reputation,
- / innovative teaching,
- / diversity and social openness.

An exhaustive assessment of this campaign will be sent to the generous donors and shared with the entire ISAE-SUPAERO community.

OSE l'ISAE-SUPAERO (Dare ISAE-SUPAERO)

A committed approach developed to promote and guarantee equal opportunity for everyone to have access to higher education:

11 high schools and 11 middle schools in the Toulouse academic region take part in the system. These 430 young people are accompanied by over 150 students, research professors, research departments and staff. Academic support, notably tutoring for disabled students, discovering the world of higher education, discovering the industrial and aeronautical sector, and scientific and technical workshops are all organized throughout the school year. GIFAS has renewed its support for these social and educational actions.

An example of a student diversity project initiated in 2018:

Thanks to the engineers, research professors and students of the Institute's Mars Club, students from 22 partner schools in the OSE l'ISAE-SUPAERO program are participating in the "Insight" space adventure. Throughout the year, multidisciplinary educational sessions on the subject of Mars exploration are offered in collaboration with their teachers. Imagination and creativity are at the heart of this wonderful, unifying adventure:

- / building Mars rovers,
- / developing an escape game,
- / capturing and studying seismic waves.



Committed to the dynamics of invention

With passion and commitment, we give the keys to education, research, initiation, innovation and business to all our students.

Every one of our students is free to dream and create to go ever further. We are here to let their projects take flight.

INNOVATION

We encourage entrepreneurship and innovation

Innov'Space: a dedicated space

Among our actions to encourage innovation and entrepreneurship, in 2019 we will be welcoming a space dedicated to these questions. More than just a prototyping space (like FabLab), InnovSpace will also have a showroom reserved to the presentation of research projects and innovation, a pre-incubator for start-ups, a space dedicated to immersive technologies and a concurrent engineering center.

Promising projects in the incubator

While awaiting the opening of InnovSpace, we are already offering a space for the hosting and pre-incubation of start-ups and spin-offs on our campus. Here are the first start-ups that have been formed:

/ U-Space provides high-quality turnkey space systems designed to facilitate access to space for all thanks to CubeSat.

/ Hinfact (start-up in man-machine interface sector).

/ Speeryt, based on the Tetrys software developed at the Complex System Engineering Department (DISC), offers a solution improving data transmission by optimizing the reliability/speed couple. Available through a commercial license, this product is in the test phase with several industrial customers in the fields of aeronautical equipment, video in telephony, drones etc.

/ Diodon, created by two ISAE-SUPAERO students and which produces inflatable drones (patented), made its first sales and has pumped up its growth by recruiting its first employees.

/ Greenvest Solutions, founded by a student.

ISAE-SUPAERO proposes an analysis of satellite data to identify the best opportunities for the renewable energy sector. The Greenvest Solutions team recently won Act In Space, an international challenge organized by CNES and ESA!

IDEA, our unit specialized in the digital transformation

Digital Learning is a major challenge for ISAE-SUPAERO. We have been working on this for a number of years, with several experiments and operational prototypes in the field of teaching with digital technologies. The Institute recently set up a specialized unit in the field of digital transformation to breathe new life into this transformation. This unit, called IDEA, for "Innovative Digital Education for Aerospace", fulfils a mission of consulting, expertise, monitoring and support in digital transformation for the entire Institute. IDEA is the privileged contact in this transformation for all players at the Institute and for outside correspondents. Actions have been carried out, notably in favor of digital learning. This includes, for example, the production of innovative training products that make full use of digital technologies, such as "MOOC Avion" and its annual replay over the past 4 years, with a total of over 15,000 people enrolled. More recently, two MOOCs have been developed in English: DynaMOOC – Understanding and applying dynamics, and Airplane MOOC – How do planes fly? They will be streamed at the start of 2019 on the FutureLearn international platform.





Moments of the year

“Tomorrow is our purpose”: our brand film

At the end of 2018, we presented our brand film, “Tomorrow is our purpose”. Produced in French and English versions, this short institutional film aims to consolidate the Institute’s position as a world leader in higher education for aeronautical and space engineering. This manifesto breaks with the codes and the traditional world of higher education and research; it draws upon emotion to inspire the viewer.

Participation in the Trophées de l’Aéronautique

For the 6th edition of the Trophées de l’Aéronautique (Aeronautics Trophies) at the Musée Aeroscopia in Toulouse, we hosted a “Research & Innovation Village”.

The aim was to talk about the new synergies between the world of higher education and research, and the world of economics and industry.

Our researchers and students at the “European Researchers Night”

At the “European Researchers Night” at the Cité de l’Espace, the Institute presented its research activities and its researchers.

There were discussions and explanations around a model of a Mars base, a 3D visit to the MDRS Mars simulation base, and a TELEOP experiment to measure an astronaut’s performances during teleoperation activities.



Thomas Pesquet, 2018 Commencement Speaker

The symbolic Graduation Ceremony for Engineers at ISAE-SUPAERO and ENSICA was held in November 2018. It was a special occasion because it was the last graduating class from the ENSICA program. The graduates and their families will never forget the speech given for the occasion by Thomas Pesquet, SUPAERO Class of 2001.

5 awards for our students at the ICAO simulation

The International Civil Aviation Organization’s (ICAO’s) diplomatic simulation took place in Montreal in May 2018, aiming to place students in real situations of high-level diplomatic and technical discussions. For the occasion, the team of ISAE-SUPAERO students from the Master 2 in Space Activities and Telecommunications Law gave an excellent performance, as they took 5 awards:

- Award for the most honorable delegation*
 - Award for the best paper of intention in the safety committee*
 - Award for the best paper of intention in the economic committee*
 - Award for the best paper of intention in the environment committee*
 - Award for the best delegates to the environment committee*
- The team received support from the ISAE-SUPAERO Foundation.



Destination Mars for 7 of our engineering students

From February to March, 2018, seven ISAE-SUPAERO engineering students had an original experience as astronauts on board a research station set up in the Utah desert, in the United States: the Mars Desert Research Station (MDRS). This mission was designed to improve our scientific knowledge for the human exploration of Mars. These 7 budding astronauts dream of one day being part of the next missions to the Moon and Mars.



Moments of the year



“Stop preconceived ideas”: ISAE-SUPAERO Open House Days

As part of the Science Festival, this year organized on the theme of preconceived ideas, ISAE-SUPAERO and ENAC opened their campus up to the public. The program for the day included many preconceived ideas to be explained and deconstructed with the public (“Mechanics is for girls”, for example), during visits to the laboratories and scientific demonstrations.

Simulation of Martian life at the Lunares base

Simon Bouriat, a 3rd-year engineering student, and Patrick Fleith, a 2017 MS TAS Astro graduate, have been selected to take part in the ARES III mission – a simulation of a Mars mission at the Lunares base in Pila, Poland – August 4th to 19th, 2018.



ENAC and ISAE-SUPAERO students together for Airexpo

For several decades, students from ENAC and our students team up to organize the famous Airexpo meeting at the Muret-Lherm site. An event not to be missed for aeronautics enthusiasts.



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