



**ENSTA  
BRETAGNE**

# **ANNUAL REPORT 2019**



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Hervé Guillou, CEO of Naval Group and « godparent » to the ENSTA Bretagne 2019 cohort, presided over the 49th graduation ceremony, 30 November 2019.

Joël Barre, General Delegate for Armaments, on a visit to ENSTA Bretagne and its research center on 10 October 2019.



ENSTA Bretagne received representatives of the Agence de l'Innovation de Défense (AID) [Defense Innovation Agency], on 1 February 2019.



# OFFICE

## 2019 has been an exceptional year.

The investments made in science over several years have now come to fruition with the opening of a new, 1 600 m<sup>2</sup> research facility housing material platforms that can measure down to the nanometric scale, and the total renovation of a 750 m<sup>2</sup> building for hi-tech cybersecurity equipment.

This year's new intake has confirmed the relevance of these investments. The school is once more the leading choice of students taking the Mines-Télécom competitive entrance exams.

In consistency with the scientific investments, the excellence of the candidates recruited from preparatory classes is equaled by the high level of associate professors who have joined us. ENSTA Bretagne attracts the best candidates in both training and research.

The success of the new 2019 academic year was also appreciated by the co-operative [apprentice] engineers now numbering more than 50 students in each year.

The new 2019 school year was also successful in terms of diversity, with girls making up more than a third of the first year. The many encouragements have paid off and will be renewed to ensure this rebalancing lasts.

Finally, apart from this attractiveness, our reward is the speed at which our graduates find work, and progress in their career, in our 10 fields of expertise.

This success was enjoyed during the graduation ceremony in November 2019. 350 new engineer, master and doctoral graduates, on very diverse missions, made up the 49<sup>th</sup> ENSTA Bretagne cohort, "godparented" by Hervé Guillou.

ENSTA Bretagne's research, partnerships and innovation, recognized by the creation of a joint laboratory with **Naval Group on Intelligent Naval Embedded Systems** and a chair with Thales on Autonomous Marine Observation Systems are the driving forces behind our success.

## On the strength of its results, ENSTA Bretagne has become a graduate engineering school and research institute of world-wide renown

The high level and volume of our scientific production, focusing strongly on civil and military industrial applications with numerous companies, the DGA and AID, make ENSTA Bretagne a cornerstone for research.

The school is involved in European, national and regional, multi-year, multidisciplinary programs for a wide range of applications: maritime, defense, transport, aerospace, energy and digital technologies. Whether the advances concern future technology or transport, it is most often the environment which is at stake.

In information technology and mechanical sciences, ENSTA Bretagne takes up these challenges within its renowned, multi-establishment laboratories (UMR of the CNRS, Lab-STICC and IRDL) and also the chairs and joint laboratories with industry, the new research units such as the FoAP Laboratory on professional and apprenticeship training, and the ISBLUE university graduate research school dedicated to promoting the sciences and technologies of the sea (future investment programs) worldwide.

These partnerships are both close and productive. They support international development which is already well established and has increased in 2019, in Australia, on the American continent and Europe. The award of the highest level (3 stars) of the "Bienvenue en France" label and the high placing of ENSTA Bretagne in the Figaro-Etudiant ranking of graduate engineering schools have confirmed our strategies and our ambitions. **Thank you to everyone for your confidence and your involvement.**



**Ronan Stéphan**  
President of ENSTA Bretagne  
Board of Directors, Scientific  
Director of Plastic Omnium

**Pascal Pinot**  
Director

Since July 2020, Mr Gruselle has succeeded Mr Pinot as Director of ENSTA Bretagne

✉ [directeur@ensta-bretagne.fr](mailto:directeur@ensta-bretagne.fr)

A person with their hair in a bun, wearing a red t-shirt, is leaning over a laptop in a workshop. In the background, a blue and white humanoid robot is visible. The scene is lit with a cool blue light. A decorative graphic of white wavy lines is overlaid on the image, starting from the left and curving across the middle. The text 'MISSIONS & AMBITIONS' is written in large, bold, white capital letters across the bottom half of the image.

# MISSIONS & AMBITIONS

# WORLD CLASS GRADUATE ENGINEERING SCHOOL AND RESEARCH INSTITUTE

## A VENERABLE INSTITUTION

- Built on 200 years of training experience
- Campus situated in Brest since its creation
- Public establishment under the supervision of the French Ministry for Armed Forces
- Military and civilian training and research activities
- Cutting edge fields of expertise
- Wide-ranging and rare disciplines

## A SCHOOL IN RAPID DEVELOPMENT

Since the beginning of the 2000s, ENSTA Bretagne has greatly developed its training and research activities, attracting increasing numbers of students, PhD students and high level researchers and teaching staff. This trend is continuing and heightening its international renown.

- Students: X 2 in 15 years | PhD students: X 4 in 15 years

**966**  
STUDENTS

**585** of whom  
are MSc students  
and **116** are PhD

**20%**  
INTERNATIONAL  
students

**22%**  
MILITARY  
students

ENSTA Bretagne holds a unique position in the top 25\* French graduate engineering schools"

- French and international leader in marine and defense engineering
- A quality management system certified ISO 9001 [v2015] for all of its activities.

## PARTNER SECTORS



OFFSHORE, NAVAL INDUSTRIES & ENERGY



DEFENSE & SECURITY



INFORMATION TECHNOLOGIES & OBSERVATION SYSTEMS



AERONAUTICS & SPACE



AUTOMOBILE INDUSTRY & LAND VEHICLES



TEACHING & RESEARCH

\* **2<sup>nd</sup> place in the General and Multidisciplinary** classification of the Figaro Etudiant French graduate engineering school ranking [December 2019, [bit.ly/ClassmtLeFigaro19](http://bit.ly/ClassmtLeFigaro19)].

# OUR MISSIONS

Choosing to study, teach, innovate, and lead research at ENSTA Bretagne means choosing excellence, an open door to the world and access to an exceptional network of renowned hi-tech companies and scientific organizations.



## TRAINING

ENSTA Bretagne trains general and high level specialist engineers who are immediately operational and have great potential. The quality of training at ENSTA Bretagne is renowned. Its graduates are rapidly recruited for the positions which interest them, in the most innovative of sectors.

ENSTA Bretagne graduates have various profiles, but one vocation which is to take part in innovative projects in design, R&D, measurements, tests or program management. They are prepared to evolve to face the major challenges of cutting edge industries and society, sustainable development, future transport, digitization, cybersecurity, maritime and space exploration...

ENSTA Bretagne is at the heart of an exceptional national and international network composed of hi-tech companies, academic institutions, civil and military test centers.

Many double degrees enable the students to personalize their career paths and enhance their international prospects.

**290**  
GRADUATES  
in 2019

— ○ —  
**3**  
TRAINING  
AND RESEARCH  
DEPARTMENTS

MECHANICAL SCIENCES  
INFORMATION  
& COMMUNICATION SCIENCES  
HUMAN & SOCIAL SCIENCES

— ○ —  
**15**  
TRAINING CYCLES

 pages 24 to 29



## RESEARCH

A cornerstone for excellence in teaching, major multi-disciplinary research is carried out on campus, which is geared towards industrial, civil and military applications. The research programs are regional, national and international. The high-level scientific production is intense and constantly increasing, involving numerous partners. ENSTA Bretagne research teams are assigned to multi-supervisory academic laboratories (IRDL, Lab-STICC, FoAP) and joint research structures with industry. The Research Institute has access to unique experimental facilities to characterize phenomena and validate scientific results, in mechanical sciences (the MASMECA technology platform) and information technologies (the Cyber Center, an anechoic chamber, the robotics pool, hydrographic vehicles, drone systems etc).

**228**  
RESEARCHERS  
ENGINEERS  
TECHNICIANS  
& PHD STUDENTS

— ○ —  
**3**  
ACADEMIC  
LABORATORIES

— ○ —  
**8**  
CHAIRS  
AND JOINT  
LABORATORIES

👁️ pages 32 to 51

## INNOVATION

The implementation of scientific work and participation in strategic territorial planning have won ENSTA Bretagne an outstanding position in the socio-economic world. The creation of the ENSTARTUPS incubator and an impressive program of entrepreneurship awareness training have added to ENSTA Bretagne's innovation policy since 2017.

👁️ pages 30 to 31



# INCREASING INTERNATIONAL RENOWN

Because our scientific teams participate in leading edge international programs, with numerous partners throughout the world, and fully aware of the importance for our students to acquire a strong international, cultural outlook, international partnerships are a core element of the school."

**NUMEROUS  
INTERNATIONAL  
PARTNERS  
IN TRAINING  
AND RESEARCH**

**91**  
PARTNERSHIP  
AGREEMENTS  
IN 30 COUNTRIES  
in addition to multiple  
scientific partnerships

**30**  
INTERNATIONAL  
MSC AS DOUBLE  
DEGREES





**JANUARY 2019**  
**INAUGURATION**  
**OF THE GRADUATE**  
**RESEARCH**  
**UNIVERSITY**  
**"ISBLUE"**

ISBLUE is the concentration of the best higher education in marine sciences and technologies have to offer: 9 leading Breton establishments (2 universities, 3 research organizations, 4 graduate engineering schools including ENSTA Bretagne). Isblue was selected and financed within the Investments for the Future (PIA) framework. It is the only French graduate school in sea studies, confirming the Breton Peninsular's leading position in higher education in this strategic field.

The result of close collaboration of the 9 partners and economic stakeholders, Isblue aims to increase awareness of its offer of excellence in masters and doctorates on an international level, to encourage international mobility and create new courses and scientific projects.



**OCTOBER 2019**  
**AWARDED**  
**THE HIGHEST LEVEL**  
**OF THE "BIENVENUE**  
**EN FRANCE" LABEL**

Created in 2019 by Campus France, the "Bienvenue en France" label aims to guarantee the quality of reception of international students in French higher education establishments, universities and graduate schools. Having passed at all levels, ENSTA Bretagne obtained 3 stars, the highest level of accreditation, and is among the first French engineering schools to obtain this distinction.

The label is awarded based on 20 criteria organized into 5 major categories:

- Quality and access of information
- Quality and access to the facilities
- Quality and access to training
- Accommodation and quality of life on campus
- Quality of post-graduation follow-up

## CONTACT

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**2019**  
**EXTENSION AND CONSOLIDATION**  
**OF OUR MANY PARTNERSHIPS WITH AUSTRALIA**

The partnerships commenced in 2018 following the signing of "the contract of the century" for 12 submarines for Australia, to be built by Naval Group, which also included training and research.

- The first year for the Franco-Australian double degree "Ships and Submarines" with the University of Adelaide (UoA).
- The first summer school for Australian students in Brest, organized by the WASAA Consortium (Western Alliance for Scientific Actions with Australia) composed of ENSTA Bretagne, IMT Atlantique, ENIB, Ecole Navale, UBO and UBS.
- ENSTA Bretagne, Flinders University and Naval Group formalized the creation of a partnership in Autonomous Robotics, a field of excellence of the

two academic partners (cf. photo)

- Reception of ENSTA Bretagne professors and students in Australian research centers and Australian researchers and students hosted by ENSTA Bretagne's Research Institute  
> *testimonies of the Australian students who were awarded the « Nicolas Baudin » mobility grant : [bit.ly/NBaudin19](http://bit.ly/NBaudin19)*
- Participation of ENSTA Bretagne in an International Research Lab in Australia, with Naval Group and the Lab-STICC.
- Joint thesis supervision agreement with Curtin University, Perth.
- ENSTA Bretagne became a member of the SmartSat CRC, a consortium of universities and research bodies created by the Australian government to encourage innovation and information technologies ([smartsatcrc.com](http://smartsatcrc.com)).

# A SCHOOL GEARED TOWARDS HI-TECH COMPANIES

ENSTA Bretagne has many long-lasting partnerships which are growing in number in France and throughout the world. The companies and DGA centers are involved in school life in many ways.

## IN TERMS OF TRAINING

- Provision of engineers and experts for the courses or exam juries
- Presence at careers fairs
- Study and design subjects proposed to the teachers to lead group and mentored projects, in the 2<sup>nd</sup> and final year (MSc level)
- Assistant engineer internships [3 to 5 months] or final year projects [5 to 6 months]
- Professionalization contracts
- Co-operative [apprenticeship] contracts
- Staff training for companies

## IN TERMS OF RESEARCH

- Research contracts
- CIFRE Theses (Conventions Industrielles de Formation par la Recherche, an industrial "training through research" agreement)
- Tests and measurements
- Joint laboratories
- Research chairs

The school collaborates with industry on countless projects in training, research and innovation. This guarantees a perfect harmony between the training and the companies' expectations in terms of training, the speed of employment for the graduates and a structuring balance between fundamental and applied research. "

## SCHOOL LIFE

- "God parenting" [patronage] of a cohort
- Participation in governing boards, training, research, and company relation committees
- Financial support: apprenticeship tax, ENSTA Bretagne scholarship, sponsoring of student projects

**150**  
ENGINEERING  
PROJECTS

Accomplished by groups of students on themes connected to industry and public works



Video of industrial project  
viva voces  
[bit.ly/ProjetsIndus2A](https://bit.ly/ProjetsIndus2A)

pages 28 to 29

**450**  
ENGINEERING  
INTERNSHIPS

3 to 6 months in  
companies and research  
centers in France  
and abroad

**>1000**  
COMPANY  
PARTNERSHIPS  
IN FRANCE  
AND WORLDWIDE

## FOCUS

# TWO DEDICATED COHORT "GODPARENTS"

They have enabled ENSTA Bretagne to extend its relationship with its two historical partners, the 2<sup>nd</sup> and 3<sup>rd</sup> main employers of the school's graduates: respectively Naval Group and Thales.



### APRIL 2019

**Pierre Éric Pommellet**, Executive Vice President, Operations and Performance of the Thales Group, "godparent" (patron) to the cohort which will graduate in 2021, baptized them "Jean-Loup Chrétien" after his friend, the famous astronaut. The latter surprised the students when he put in an appearance during a ceremony conducted by these two mentors, which extremely motivational and very inspiring for the future engineers. Then, Pierre Éric Pommellet and Pascal Pinot renewed the partnership agreement between Thales and ENSTA Bretagne. The research partnerships were extended and a research chair entitled "TRANSNUM" was created, also involving the ISEN, and dedicated to digital technologies used for the cybersecurity of the maritime world.

<http://bit.ly/bapteme2019>

### NOVEMBER 2019

**Hervé Guillou**, Chairman and Chief Executive Officer of Naval Group and "godparent" (patron) to the ENSTA Bretagne cohort 2019, baptized "Gustave Zédé" praised the performance of the students during the graduation ceremony when many awards were bestowed.

At this event, he announced his creation of a second joint laboratory between Naval Group and ENSTA Bretagne entitled "SENI", on intelligent naval embedded systems and extended the joint laboratory "Gustave Zédé" focusing on the fatigue of material used in naval construction. He also contributed towards the school's Australian venture.

<http://bit.ly/Palm19>



## EXCLUSIVE EXPERTISE IN CONTINUING PROFESSIONAL EDUCATION

Because ENSTA Bretagne's fields of expertise satisfy specific company requirements, the word has spread in the industrial world, and accordingly the school's offers for continuing professional education have been galvanized and enhanced.

Most usually, its short courses are organized at ENSTA Bretagne, but they sometimes take place in company. They mainly cover 5 disciplines: naval architecture, electronic engineering, hydrography & oceanography, general mechanics and pyrotechnics.

### CONTACT

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**333**  
DAYS OF CONTINUING  
PROFESSIONAL TRAINING  
DELIVERED IN 2019



## HYDROGRAPHY & OCEANOGRAPHY (CAT. A)



Brest is the birthplace of this discipline and ENSTA Bretagne is the only school where you can find French training in Category A Hydrography (the highest level awarded by the FIG-OHI-ACI<sup>1</sup>). It is also one of the most renowned in the world.

Hydrography and Oceanography cover the methods used to describe and measure oceans, seas, lakes and water courses. This information is essential for all activities which are conducted at sea, around coasts or on rivers. 3 profiles are proposed:

- Hydrography
- Physical oceanography
- Marine geophysics.

The students have access to cutting edge equipment (a hydrographic survey vessel, amphibious vehicle, probes...), an environment which facilitates their application (the Brest Roadstead, Lake Guerlédan) and a variety of projects (cartography, research on wrecks, dam inspections, etc...).

### OUR TRAINING COURSES

- Specialization in the 2<sup>nd</sup> and 3<sup>rd</sup> years of general engineer training\*
- “Hydrography” Master (category A)
- Double Degree Research Master in “Marine Geophysics” or “Climate and Ocean Physics”
- Doctorate

\* i.e. MSc [4 and 5 years post High School Certificate]

### THE LABORATORIES

- LAB-STICC Laboratory [UMR CNRS6285] *cf. pages 40 to 47*
- UMR Adaptation and Diversity in the Marine Environment [Station Biologique de Roscoff, CNRS / Sorbonne University]

<sup>1</sup> Fédération internationale des géomètres - Organisation hydrographique internationale - Association cartographique internationale



## AUTONOMOUS ROBOTICS



The scientific challenges are numerous: robot autonomy, coordination, stealth... Within this context of increased research and extremely diverse applications, the training provides the keys to designing, making, programming and testing autonomous and mobile robots, to carry out all types of missions on land, at sea and in the air.

Leading robotics projects requires many skills in:

- Mechanical design
- Signal detection and processing
- The use of multiple sensors
- Perception, artificial intelligence

Through combining telecommunications, digital circuits, computer science and security, ENSTA Bretagne-trained engineers and doctors are equipped with a set of skills sought after worldwide by industrialists in many sectors of activity and research laboratories.

### OUR TRAINING COURSES

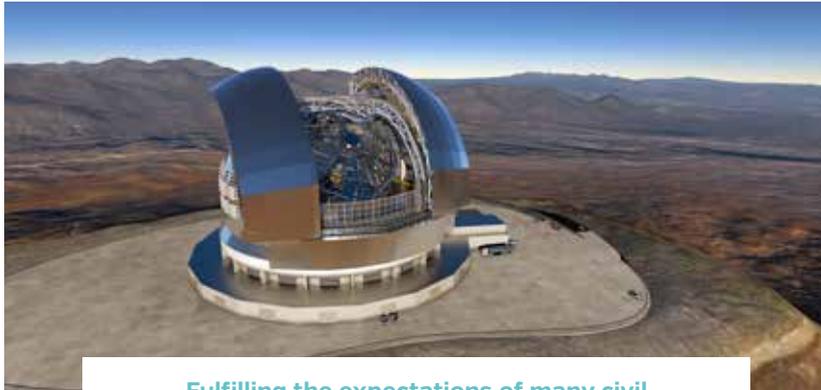
- Specialization in 2<sup>nd</sup> and 3<sup>rd</sup> years of general engineer training\*
- Master in Mobile Robotics
- Doctorate

### THE LABORATORIES

- LAB-STICC Laboratory [UMR CNRS6285] *cf. pages 40 to 47*
- Joint chairs and laboratories [with Thales and Naval Group]



## OBSERVATION SYSTEMS AND ARTIFICIAL INTELLIGENCE



Fulfilling the expectations of many civil and military companies and public bodies, ENSTA Bretagne has amassed a broad range of expertise in the design of embedded systems, multi-sensor observation systems and advanced technologies of information processing for decision support.

To imagine and design tomorrow's embedded intelligence and observation systems, the training and research employs advanced techniques in artificial intelligence which answer the issues raised by heterogeneous and mass data acquisition, processing and analysis. It includes the modeling of physical phenomena, mono or multi-sensor systems experimentation and simulation, systems engineering, mastery of embedded observation systems, the analysis, processing and interpretation of data (signals, images...) as well as decision support (decision and estimation theory).

### OUR TRAINING COURSES

- Specialization in the 2<sup>nd</sup> and 3<sup>rd</sup> years of general engineer training or co-operative (apprentice) engineer training in "Embedded Systems"
- "Multi-sensor and Localization Systems Engineering" Specialized Advanced Master
- Doctorate

\* i.e. MSc [4 and 5 years post High School Certificate]

### THE LABORATORIES

- LAB-STICC Laboratory [UMR CNRS6285] cf. pages 40 to 47
- Joint chairs and laboratories (with Thales and Naval Group)



## SECURITY AND DIGITAL SYSTEMS



**New**  
The "Port and Maritime Systems Cybersecurity" Specialized Advanced Master will open in the new 2020 academic year (with IMT Atlantique, Ecole Navale and ENSM).

This expertise concerns the design of secure communicating digital systems, incorporating telecommunications, digital circuits, computer science and security (cybersecurity, reliability and protection of personal information).

The idea is to design the most reliable and long-lasting systems. Extensive research aims to develop high level, methodological approaches, based mainly on software engineering for embedded systems and model-driven engineering. In cybersecurity, ENSTA Bretagne brings students a complete overview, from the antenna and analog chain to threat analysis. The lessons cover the entire chain, software and material architecture modeling, the exploitation of sensor-derived information, setting up telecommunications, software development and ensuring system security from the design phase onwards.

### OUR TRAINING COURSES

- Specialization in the 2<sup>nd</sup> and 3<sup>rd</sup> years of general engineer training or co-operative (apprentice) engineer training in "Embedded Systems"
- "Architecture and Security of Software and Electronic Systems" Master
- "Computer Science" Master, "Autonomous and Intelligent Interactive Systems" option.
- Doctorate

### THE LABORATORIES

- LAB-STICC Laboratory [UMR CNRS6285] cf. pages 40 to 47
- Cyber Defense of Naval Systems Chair
- [www.chaire-cyber-navale.fr](http://www.chaire-cyber-navale.fr)



## OFFSHORE AND NAVAL ARCHITECTURE



ENSTA Bretagne conducts the highest ranked training in France in offshore and naval architecture engineering and leads many research projects on the naval systems of the future, so that maritime transport is adapted for major challenges and more respectful of the environment.

With this exceptional training, the graduates design all types of vessels, submarines and naval platforms. All the parameters required for the optimum operation of a ship are taken into consideration: hydrodynamics, aerodynamics, durability, stability, propulsion, structural calculations, maneuverability, seaworthiness, ergonomics etc. The research focuses on improving the performance of the ships, especially in terms of propulsion.

### OUR TRAINING COURSES

- Specialization in the 2<sup>nd</sup> and 3<sup>rd</sup> years of general engineer training or co-operative (apprentice) engineer training\*
- "Maritime Engineering" Master
- "Naval Hydrodynamics" option "Marine Sciences" Master
- Offshore and Naval Architecture and Ship Design/Marine Engineering" Specialized Advanced Master
- Doctorate

### THE LABORATORIES

- The Dupuy de Lôme Research Institute (IRDL, UMR CNRS6027) cf. pages 34 to 39

\* i.e. MSc (4 and 5 years post High School Certificate)



## MARINE RENEWABLE ENERGIES (MRE)



Producing electricity from marine renewable energies (wind, wave, currents etc) depends on marine and submarine platforms which are innovative and resistant to the harsh conditions at sea. The training (which is unique in France) and research programs focus on their development.

One year of specialized advanced master (6 years post High School Certificate), 100% dedicated to MREs, trains engineers, future project managers or program directors. Accredited by the Conférence des Grandes Ecoles and endorsed by the Pôle Mer Bretagne Atlantique, it has brought together ENSTA Bretagne, Ecole Navale, IMT Atlantique, UBO, Ifremer and companies. The school has produced over one hundred experts in 10 years, 90% of whom have joined the national and international MRE sector. With the *Institut pour la Transition Energetique "France Energies Marines"* (the Institute for Energy Transition dedicated to Marine Renewable Energies), the research focuses on the mechanical behavior in situ of wind and wave turbines (resistance, materials, assemblies, blades, anchor lines, IMR vessels) and the modeling of the marine environment (currents and seabeds).

### OUR TRAINING COURSES

- "Expert in Marine Renewable Energies" Specialized Advanced Master
- Doctorate

### THE LABORATORIES

- The Dupuy de Lôme Research Institute (IRDL, UMR CNRS6027) cf. pages 34 to 39
- The Lab-STICC Laboratory (UMR CNRS6285) cf. pages 40 to 47

## VEHICLE ARCHITECTURE



Long term partner of the automotive industry and the entire land vehicle sector, the school trains high-performing designers who are most respectful of the environment. Including applied research and a European master, engineers having followed this training have excellent career opportunities in France and abroad.

Starting from solid foundations in mechanical design, the students move on to the major issues of the sector such as environmental norms, and new motorization, the reduction of vehicle weight, reliability, active and passive safety systems, vehicle habitability, up to the qualification of dynamic performance. The professors focus on fatigue, lifespan, deformation and the in-service behavior of materials and structures. This strategic research is geared towards validating choices made in terms of reducing vehicle weight and reducing consumption.

### OUR TRAINING COURSES

- Specialization in the 2<sup>nd</sup> and 3<sup>rd</sup> years of general engineer training, or co-operative (apprentice) engineer training\*
- International Master in Automobile Engineering
- Doctorate

### THE LABORATORIES

- The Dupuy de Lôme Research Institute (IRDL, UMR CNRS 6027) *cf. pages 34 to 39*
- OpenLab "Computational Mechanics" (with the PSA Group)

\* i.e. MSc [4 and 5 years post High School Certificate]

## ADVANCED MODELING OF MATERIALS AND STRUCTURES



Using new materials and assembly techniques is a growing trend. This involves solving the complex sizing challenges required for many activity sectors where the highest level of mechanical performance is crucial: aeronautics, the naval and automobile industries, energy, defense, the biomedical industry etc.

Optimization through modeling is necessary in all fields, to reduce the environmental footprint of human activities, to adapt to new norms, or to seize opportunities and develop new markets (new materials, innovative procedures, new energies etc). These courses are based on high-level research aiming to characterize and model the mechanical properties of all types of materials and structures. This applied research is carried out in close collaboration with numerous industrialists. Under these conditions, the use of composites, light alloys, biomaterials and adhesively-bonded structures can become more commonplace.

### OUR TRAINING COURSES

- Specialization in the 2<sup>nd</sup> and 3<sup>rd</sup> years of general engineer training\*
- "Design Engineering" Master, "Mechanics, Materials and Civil Engineering" option
- Doctorate

### THE LABORATORIES

- The Dupuy de Lôme Research Institute (IRDL, UMR CNRS 6027) *cf. pages 34 to 39*
- Gustave Zédé Joint Laboratory (with Naval Group)



## PYROTECHNIC SYSTEMS



Unique in France, this training dedicated to pyrotechnics focuses on the analysis and design of explosive systems and their integration into mechanical systems

Mastering explosive effects and designing propulsion systems can only be achieved through the acquisition of high level expertise. Many activity sectors are concerned: defense, the aerospace and automobile industries, public works or even the prevention of industrial hazards. The innovations concern energetic materials which are safer for their users, as well as the attenuation of blast effects. These dominant trends form part of the syllabuses and are the subject of research on campus. ENSTA Bretagne has extensive experimental facilities dedicated to the study of dynamic phenomena: shock wave propagation, combustion, blast effects, impacts etc.

### OUR TRAINING COURSES

- Specialization in the 2<sup>nd</sup> and 3<sup>rd</sup> years of general engineer training\*
- “Pyrotechnics and Propulsion” Specialized Advanced Master
- Doctorate

### THE LABORATORIES

- The Dupuy de Lôme Research Institute [IRDL, UMR CNRS 6027] *cf. pages 34 to 39*
- Joint laboratory with Centigon

\* i.e. MSc [4 and 5 years post High School Certificate]



## ENGINEERING AND BUSINESS SCIENCE



As a complement to the engineering sciences and core subjects in Human Sciences, this trains managers, project leaders and entrepreneurs.

This specialization in management opens up a wider range of responsibilities in companies or public bodies for the graduates. It encompasses business engineering, project, innovation, performance and intercultural management in an international context. Other students choose a one year course dedicated to maritime project management, which encompasses the concept of a maritime project, the management of an international team, quality evaluation and the management of partnerships. Innovation training is also an original research field at ENSTA Bretagne, including the study of French and international curricula used to train tomorrow’s innovators.

### OUR TRAINING COURSES

- Specialization in the 3<sup>rd</sup> year of general engineer training or co-operative (apprentice) engineer training\*
- “Maritime Project Management” Specialized Advanced Master
- Doctorate

### THE LABORATORIES

- The “Formation et apprentissages professionnels” [Professional Apprenticeship and Professional Training] Research Unit [FoAP, EA 7529]

# OUR PARTNERS AND NETWORKS

AID :  
**1 BILLION €**  
IN RESEARCH  
AND INNOVATION  
IN 2020



**132**  
MILITARY ENGINEERING  
STUDENTS (IETA)  
FOR THE ACADEMIC  
YEAR 2019



ENSTA Bretagne  
has developed a  
strategic partnership  
with IMT Atlantique  
through multiple short,  
mid and long term  
projects, such as the  
creation of new training  
courses, international  
development and social  
responsibility projects.

In both training and research, ENSTA Bretagne has developed close relationships with many public and private bodies. The school is at the heart of a vast network of companies, competitiveness and other clusters, laboratories, universities and graduate engineering schools.

## SUPERVISION

ENSTA Bretagne is part of the group of graduate schools under the supervision of the **DGA** (*Direction Générale de l'Armement* or French Technology and Procurement Agency), part of the French Ministry of Armed Forces, together with the Ecole Polytechnique, ISAE-Supaero and ENSTA Paris. The **AID** (*Agence de l'Innovation de Défense* or Defense Innovation Agency), and the training and research led at ENSTA Bretagne form part of the expertise, testing and engineering force of the DGA, the technology centers and its group of industrial partners. Moreover, from the very beginning, ENSTA Bretagne has trained the *Ingénieurs des Etudes et Techniques de l'Armement* (IETA), or Armaments Studies and Technology Engineers, who direct the DGA's programs.

## PARTNER GRADUATE SCHOOLS

Apart from its international partners (*cf. page 12*) and its research laboratory partners (*cf. pages 33 to 51*), ENSTA Bretagne proposes various academic paths for its students, as a gateway to double degrees or other courses at our partner graduate schools: IMT Atlantique, ENSTA Paris, ISAE-Supaero, ENSG, ENS Cachan, INSTN, the Polyméca network, IAE Brest, Audencia, ENSA Paris La Villette graduate school of architecture... united by the same exacting standards as ENSTA Bretagne.

## INNOVATION AND ECONOMIC DEVELOPMENT

ENSTA Bretagne plays an active role in many civil and military innovation programs and the strategic planning which defines them. The school is involved on an international, national, regional and local level.

- Competitiveness clusters: Pôle Mer Bretagne Atlantique (maritime economy), ID4CAR (automobile), Images et Réseaux, EMC2 (future manufacturing technologies), Aerospace Valley
- Institut pour la Transition Énergétique (ITE) France Énergies Marines (marine renewable energies)
- Institut de Recherche Technologique (IRT) Bcom (digital innovation).
- ORION innovation cluster in naval defense
- Pôle d'Excellence Cyber (PEC) cyber excellence cluster
- "Laboratoire d'Excellence" CominLabs on information and communication sciences

# MEMORABLE MOMENTS IN 2019



**2 FEBRUARY**  
**OPEN DAY**  
Over 650 visitors and candidates

**8 MARCH > 5 APRIL**

**SCHOOL LIFE**  
Promotion of equality and women's rights on campus: exhibitions, films, talks and impro. theater

**11 MARCH**  
**ENTREPRENEURSHIP**  
3 day seminar for 35 3<sup>rd</sup> year students with ENSTARTUPS and The Corner

**12 MARCH**  
Military engineers' flag ceremony

**19 MARCH**

maritime world get-together at ENSTA Paris

**RESEARCH**  
New 1 600 m<sup>2</sup> building for the mechanics laboratory

**INTERNATIONAL**  
New partnership agreement with the Polytechnic University of Catalonia (Spain)



**INTERNATIONAL**  
research secondment of Paul Gardner-Stephen, associate professor at Flinders University

## JANUARY

## FEBRUARY

## MARCH

**30 JANUARY**

**TRAINING AND RESEARCH**  
Inauguration of the École Universitaire de Recherche (EUR) ISBLUE on marine sciences, in Brest

**14 JANUARY > 01 FEBRUARY**

**INTERNATIONAL**  
23 Australian students at the Wasaa Academy summer school in Brest [6 establishments in Western Brittany]



**4 > 8 FEBRUARY**  
**TRAINING**

Winter session on Lake Guerlédan for marine robotics and hydrography experiments

**TRAINING**

Many company visits : Renault, Chantiers de l'Atlantique, DGA, SSF, RTE, IFSTTAR, General Electric...

**7 & 8 FEBRUARY**

**TRAINING**  
Geopolitics in Brest: "Overseas"



**21 MARCH**

**ENCOURAGING DIVERSITY OPEN HOUSE**  
"100 women, 100 careers : diversity in engineering!": career awareness for high school girls

**19 MARCH**

**SCHOOL LIFE**  
"Disability and Work": a workshops to ensure future engineers include people with special needs

**12 FEBRUARY**

**RESEARCH**  
New partnership on autonomous robotics between ENSTA Bretagne, Flinders University (Southern Australia) and Naval Group

**INTERNATIONAL**

- Creation of an International Research Lab in Australia, with Naval Group and the Lab-STICC
- Joint thesis supervision agreement with Curtin University (Perth)



**3 APRIL**

**INNOVATION**

Creation of ORION, an innovation cluster in naval defense in Brittany (DGA, Marine Nationale, ENSTA Bretagne, École Navale, Technopôle Brest Iroise)

**1 > 7 APRIL**

**OPEN HOUSE**

Sustainable development student week in Brest



**3 MAY**

**TRAINING**

The co-operative (apprentice) engineer program celebrates its ten first cohorts, with former students from all over France and Europe

**7 MAY**

**SCHOOL LIFE**

A new BDE [Bureau Des Élèves or Students' Union] is elected, led by Raphaëlle, the president

**27 MAY**

**CONFERENCE**

on nuclear deterrence by G. Schlumberger (DGRIS, French Ministry of Armed Forces) and Z. Gross (French Ministry for Europe and Foreign Affairs)



**4 JUNE**

**SCHOOL LIFE**

"L codent L créent": college girl students introduced to computer science presented their creations

**3 > 15 JUNE**

**RESEARCH**

"Sub-Meeting" dedicated to marine archaeo-robotics and continuation of exploration of the La Cordelière wreck with the DRASSM

**JUNE**



**6 JUNE**

**CONFERENCE**

on the Naval Sector by Hervé Guillou, CEO and Chairman of Naval Group

**17 > 21 JUNE**

**RESEARCH**

Organization of the national QPES colloquium in Brest: "Questions on Pedagogy in Higher Education: cooperation and apprenticeship". 400 specialists attended this 10<sup>th</sup> edition

**28 & 29 MAY**

**TRAINING**

2<sup>nd</sup> year projects viva voces (4 year post High School Certificate): 50 group projects were accomplished on information technologies and mechanical sciences

[bit.ly/ProjetsIndus2A](https://bit.ly/ProjetsIndus2A)



**4 APRIL**

**TRAINING**

"Job meeting": the candidates for co-operative (apprentice) engineer training meet the companies

**5 APRIL**

**"GODPARENTING"**

of the 2020 cohort, baptised "Jean-Loup Chrétien", by Pierre-Eric Pommellet and Thales

**5 APRIL**

**RESEARCH**

Creation of the research chair "Transnum" dedicated to autonomous marine observation systems by Thales, ENSTA Bretagne and ISEN Yncréa Ouest



**APRIL**

**MAY**

# MEMORABLE MOMENTS IN 2019



**26 > 30 AUGUST**

**RESEARCH**  
Organization in Brest of the Congrès Français de Mécanique: over 1000 researchers and engineers gathered together by the IRDL (*more info on page 35*)



**4 SEPTEMBER**

**TRAINING**  
"Expert in Marine Renewable Energies" Specialized Advanced Master: 10<sup>th</sup> year and graduation of the 100<sup>th</sup> expert. An undeniable success

**ALUMNI ENTREPRENEUR**  
Laurent Escalier (1999 cohort) presented a light electric vehicle for city-center deliveries

**JULY**

**AUGUST**

**SEPTEMBER**

**29 JUNE > 11 JULY**

**OPEN HOUSE**  
"Sound to See the Sea": an original animated film describing submarine acoustics, created by ENSTA Bretagne, Shom, the École Navale and Thales for the "La Mer XXL" exhibition, and viewed by the Secretary-General of the Sea, Denis Robin



**FROM 19 AUGUST**

**INTERNATIONAL**  
The international students arrive: 30 nationalities present at ENSTA Bretagne

**30 AUGUST**

**SCHOOL LIFE**  
Induction Day



**START OF THE ACADEMIC YEAR 2019**

A progressive start from mid- August to mid- September for high level students. The proportion of female students has progressed significantly, reaching 30% of the general engineer population [an increase of 10 points]

**16 > 20 SEPTEMBER**

**TRAINING**  
Military leadership course for the 3<sup>rd</sup> year students

**INTERNATIONAL**  
New partnership agreement with the University of Pardubice, in the Czech Republic

7 > 11 OCTOBER

**TRAINING**  
Guerlédan 2019/2020:  
A new campaign  
of robotic and  
hydrographic  
experiments on the lake

**INTERNATIONAL**  
Partnership agreement  
with the University  
of Genoa [Italy]

10 OCTOBER

**JOËL BARRE, DELEGATE  
GENERAL FOR ARMAMENTS**  
visits the school and the  
research institute



10 OCTOBER

**INTERNATIONAL**  
Erasmus Days:  
roundtables on the  
place and role of the  
eco-responsible engineer  
[linked to the A-STEP  
2030 project]



21 NOVEMBER

**RESEARCH**  
Renewal and  
strengthening of  
the Naval Systems  
Cyberdefense Chair [Naval  
Group, Thales, École  
Navale, IMT Atlantique and  
ENSTA Bretagne]

NOVEMBRE

**INTERNATIONAL**  
• Award of the highest level  
[3 stars] of the "**Bienvenue  
en France**" label  
• New double degree with  
the Federal University of Rio  
Grande do Sul [Brazil]  
• Agreement with Colorado  
State University with a view  
to awarding double degrees

2 DÉCEMBRE

**TRAINING**  
A day of discussions on  
career opportunities between  
1<sup>st</sup> year students and former  
students

4 DECEMBER

**RESEARCH**  
Launch of the Ker-Seveco Project  
[by ENSTA Bretagne, Mobility Tech  
Green and Kereval] to improve  
the cybersecurity of connected  
vehicles

OCTOBER

NOVEMBER

DECEMBER

17 OCTOBER

**INTERNATIONAL MORNING**  
An intercultural get-together  
of the ENSTA Bretagne  
students from different  
countries and a forum on  
international opportunities



22 OCTOBER

**TRAINING**  
Careers Fair with numerous  
companies and the DGA

27 > 31 OCTOBER

**INTERNATIONAL**  
22 European students  
come to be trained in Marine  
Renewable Energies by ENSTA  
Bretagne [organized by  
the BEST Club]

14 NOVEMBER

**ENTREPRENEURSHIP**  
Innovation evening  
for sixty young leaders  
of the CJD [Young  
Executives Center] Brest,  
organized by the  
ENSTARTUPS incubator  
and French Tech Brest +

30 NOVEMBER

**DEGREE CEREMONY 2019**  
Degrees awarded and numerous  
other awards by the "godparent"  
[Hervé Guillou CEO and Chairman  
of Naval Group] and the partners

30 NOVEMBER

**SCHOOL LIFE**  
Gala Evening at the Capucins

30 NOVEMBER

**RESEARCH**  
Creation of a 2<sup>nd</sup> joint  
laboratory with Naval Group  
dedicated to naval embedded  
intelligence systems [SENI]



5 DECEMBER

**TRAINING**  
Forum Ouest Avenir careers fair,  
organized by Brest students with  
over sixty companies present

17 DECEMBER

**ENDORSEMENT**  
of a new training program in port  
and maritime system cybersecurity  
by the Pôle Mer Bretagne Atlantique  
[open in September 2020, with IMT  
Atlantique, École Navale, ENSM]

A photograph of a diverse group of people in a training or classroom setting. The image is overlaid with a teal-colored geometric shape and a network of thin, white, curved lines that suggest connectivity or data flow. The word 'TRAINING' is written in large, bold, white capital letters at the bottom left.

**TRAINING**

# ENSTA TRAINING

## The merit, confidence and success of our students and graduates inspire our every move.

ENSTA Bretagne holds a unique position in the top 25 graduate engineering schools. The school derives its excellence from its assets such as its multidisciplinary approach, the diversity of its lessons and their originality in many fields, as well as the civilian and military mix. Our ambition and responsibility is to prepare the students for the major challenges of engineering. We offer them an environment which includes on the one hand, proximity to companies and research laboratories including on an international scale and on the other, a solid foundation in technological and methodological expertise, in addition to our propensity for teaching through projects, cultural awareness and human sciences. Again this year, the "engineer" training at ENSTA Bretagne continues to be highly solicited as demonstrated by the increasing number of candidates recruited and the largest ever intake of co-operative (apprentice) engineers. The school's attractiveness for young women is well established thanks to the wide choice of specialist fields, the school's excellent image, the quality of the career paths of our former students and the numerous initiatives led to inspire female college and high school students. Moreover, one of our female students is in charge of the Bureau Des Élèves (Students' Union), and is organizing all the student entertainment, together with her team.

The international outlook, and the multiple links with companies favor the development and evolution of the curricula. This is accompanied by the quest for flexibility and performance in the content as well as in the organization and implementation of the training programs. With my teams, I am both a witness to and part of the evolution in engineer training, the remodeling of the information and scheduling systems, the creation and transformation of masters and specialized advanced masters, all within the context of the restructuring of higher education and research, and a very strong international dynamic. A watchful eye is kept on the simultaneity of the evolutions and their stakes, as individual satisfaction and the teams' attachment to the ENSTA Bretagne project, are the keys to future development and also the guiding thread for my action. Professor and Dean of Faculty for engineer training and research for 20 years at the Ecole Navale, I succeeded Hélène Klucik at ENSTA Bretagne at the start of the 2019 academic year. Attentive to the well-being and satisfaction of the students, teachers, professors and pedagogical support teams, my mission to manage the training and the implementation of different curricula is accompanied by a particular attention to the link between training and research, and the development of the programs on offer. I thank the teams and the school's partners for their warm welcome. We are united in inventing a golden future for ENSTA Bretagne, and the success of 2019 bodes well. I invite you to discover this in the following pages.

ENSTA Bretagne is developing, ever faithful to its missions and its bedrock of expertise, committed to its partners and its environment, in perpetual evolution and its quest for innovation.



**Rémy Thibaud**  
Dean of Faculty

✉ [remy.thibaud@ensta-bretagne.fr](mailto:remy.thibaud@ensta-bretagne.fr)

# TRAINING

## ENGINEERS AND EXPERTS

### GENERAL ENGINEER PROGRAM

3 year curriculum, accredited by the CTI\* (bac+5)

ENSTA Bretagne delivers high-level multi-disciplinary training, in response to major societal and technological issues. The graduates are highly sought after by companies in France and abroad. They are immediately operational in the chosen field of expertise and able to evolve and rapidly take on responsibilities.

#### CORE CURRICULUM

- General, complete and balanced education
- Mathematics, information technologies, digital sciences, mechanical sciences, human sciences, intercultural management, societal challenges...
- Numerous implementation projects with companies
- Workshops, company simulations, leadership internship...

#### 9 SPECIALIST FIELDS TO CHOOSE FROM



#### PROFILES

- Studies and Design, R&D, assessment, tests and measurements engineer
- Armament engineer
- Research engineer
- Business engineers
- Entrepreneur engineers

#### ADMISSION

- After scientific preparatory classes, and the Mines-Telecom competitive entrance examinations: 155 places
- Or university graduate [L3,M1,M2] and application dossier

78% civilians  
22% military

49<sup>th</sup>  
cohort in 2019

30 %  
female student

Excellent admission rate 2019: The level of the students continues to progress (the school is the leading choice in the Mines-Telecom competitive entrance exams) and there is a distinct improvement in diversity.

### ENGINEER TRAINING APPRENTICE

3 year course, delivered with companies, endorsed by the CTI\* (bac+5)

A multi-disciplinary and demanding education program, mixing lessons with practical periods in companies, enabling high-potential students, mostly with technological training backgrounds (DUT, BTS) to attain the best level. The quality of the first 10 cohorts established the reputation of the training. The school is increasingly solicited by high-performing candidates

- 100% of time spent training
- 40% academic sequences
- 60% professional sequences

#### CORE CURRICULUM

- General, complete and balanced education
- Mathematics, information technologies, digital sciences, mechanical sciences, human sciences, intercultural management, societal challenges...
- Thesis and viva voce on technical themes or business culture after each professional sequence

#### 4 SPECIALIST FIELDS TO CHOOSE FROM



#### PROFILES

- Research engineer, design, R&D, testing and measurements
- Business engineer
- Engineer contractor

#### ADMISSION

- After a technical degree, 2 year post high school certificate diploma, via a dossier and interview: 50 places

40%  
in embedded systems

60%  
in mechanical sciences

11<sup>th</sup>  
cohort

The watchword for 2019 is growth, with the opening of 10 new places, bringing the number of co-operative [apprentice] engineers to 50, to which we can add those employees on continuing professional training.

\* CTI : Commission des Titres d'Ingénieur. In France, the CTI is the relevant body in charge of carrying out evaluation procedures that lead to the accreditation of the institutions to award the engineering degree.

# EMPLOYMENT SURVEY 2019

In all the special subjects, the rapid integration into the world of work of the young 2018 graduates and the increase in the average salaries confirms the reputation of the school in the business world and how the profiles of the students are a match for the challenges which await them.

**280**  
GRADUATES  
IN 2018

**97%**  
NET EMPLOYMENT  
RATE AT 6 MONTHS  
national average: 90%

**< 1 MONTH**  
AVERAGE TIME  
TO FIND FIRST JOB

**39 600 €**  
AVERAGE GROSS  
ANNUAL SALARY

Study representativeness: 98%. Annual national survey conducted by the *Conférence des Grandes Écoles* at the beginning of 2019, of 2018 graduates 6 months after graduation.

## MASTERS

2 year course, accredited by the French Ministry for Higher Education, Research and Innovation

### 6 MASTERS OF WORLDWIDE RENOWN

- **HYDROGRAPHY\***  
(category A of the international organization FIG-OHI-ACI). Carry out and assess hydrographic surveys according to the international norms for the sector
- **MARITIME ENGINEERING**  
design all types of naval systems, ships, platforms and submarines. This is associated with the MSc of Marine Engineering of the University of Adelaide (UoA) for the **Franco-Australian double degree** "Ships and Submarines"
- **MOBILE ROBOTICS AND AUTONOMOUS UNDERWATER VEHICLES\***  
Dedicated to the design and creation of mobile robotic systems, this includes the material and software
- **AUTOMOBILE ENGINEERING\***  
Unique in Europe, this international program associates 5 establishments in 5 countries: ENSTA Bretagne, the University of Prague (CTU), the University of Arnhem (HAN), the University of Chemnitz (TUC) and the University of Bandung (ITB)

### • ARCHITECTURE AND SECURITY OF ELECTRONIC SYSTEMS AND SOFTWARE

This answers all the challenges of secure communicating systems: modeling software and material architecture, exploiting information provided by sensors, installing telecommunications...

### JOINTLY-ACCREDITED MASTERS

- **"Marine Sciences" Master** (with UBO/IUEM)
  - **NAVAL HYDRODYNAMICS** option
  - **OCEAN AND CLIMATE PHYSICS** option (coastal, offshore and ocean data sciences)
  - **MARINE GEOPHYSICS** option
- **"Design Engineering" Master, MECHANICS, MATERIALS AND CIVIL ENGINEERING** option (with UBO, UBS, ENIB and INSA Rennes)
- **"Computer Science" Master, INTERACTIVE, INTELLIGENT AND AUTONOMOUS SYSTEMS** option (with UBO, ENIB and IMT Atlantique)

## SPECIALIZED ADVANCED MASTERS (MS)

1 year course, accredited by the *Conférence des Grandes Écoles*

### INTEGRATE HIGH TECHNOLOGY SECTORS OF THE FUTURE

- **CYBERSECURITY OF PORT AND MARITIME SYSTEMS\***  
**New for the 2020 academic year**  
Counter current attacks and detect future threats to defend and operate specific maritime and port systems (training endorsed by the Pôle Mer Bretagne Atlantique quality label)
- **MARINE ENGINEERING, OFFSHORE AND NAVAL ARCHITECTURE, AND SHIP DESIGN\***  
Train to become a naval architect, project leader, studies engineer, research engineer or shipyard manager. This is associated with the DPEA of the ENSA Paris La Vilette School of Architecture for the "Ship Design" option
- **MARINE RENEWABLE ENERGIES (MRE) EXPERT\***  
Design systems to harness MREs, analyze the impacts and the issues, manage MRE programs
- **MANAGEMENT OF MARITIME PROJECTS\***  
Manage, coordinate and evaluate maritime projects of international caliber (training endorsed by the Pôle Mer Bretagne quality label)
- **PYROTECHNICS AND PROPULSION\***  
Master the physical phenomena of combustion, deflagration and detonation and integrate them into a mechanical propulsion system
- **LOCALIZATION AND MULTI-SENSOR SYSTEMS ENGINEERING\***  
(with ENSTA Paris). Design multi-sensor technological initiatives

Most  
of these courses  
are unique  
in France

\* indicates that the course is unique in France

# CONDUCTING PROJECTS: ENSTA BRETAGNE'S DNA

Teaching through projects is a fundamental part of our training programs

This has been part of the fabric of the school since its very beginning. The many implementation projects led help the students to acquire a system view.

These simulations enable them to progress rapidly on the most complex problems, and to be immediately operational at the end of their studies.

The group implementation projects are on real company subjects and are supervised by the professors during semesters 3, 4 and 5.

They enable students to study and create complete deliverables in the 10 fields of expertise of the school.

## EXAMPLES OF DELIVERABLES OF THE 2020 COHORT IN THEIR SECOND YEAR (SEMESTER 4)

- "DEROBAT": creation of a demonstrator capable of mapping the sea floor with the help of autonomous robots for the universal "La Mer XXL" exhibition [Nantes July 2019]
  - "Lifting aid" for the Meunier SA company. The students designed a mechanical system enabling 70kg to be easily transported
  - "Hydrographic surveys of the Brest Roadstead", completed using ENSTA Bretagne's hydrographic survey vessel (La Panopée) with a multibeam, single beam and sidescan sonar, then the data was processed to produce a bathymetric map
  - "Intelligent Parking" how to ensure traffic flow in Brest during the July 2020 Maritime Festival. The City authorities entrusted this subject to ENSTA Bretagne students who have designed a parking lot detection system that monitors arrivals and departures enabling a real time plan of available spaces
- > + *business simulation : 3 days to save a company in financial difficulty*  
<http://bit.ly/JEUentreprise>
- "Glue levitation" for PSA: The aim was to lighten vehicle roofs using aluminum and ensuring the performance of adhesively-bonded assemblies. The students succeeded in levitating a drop of glue, designing a curing system and measuring the volumetric evolution of the glue sample.
  - "Gardening and Domotics": the team designed an autonomous and automatic garden controlled over the Internet. Humidity, light and temperature sensors enabled continuous monitoring of the ecosystem.



## FOCUS

### Projects completed by the 2019 "Maritime Project Management" Specialized Advanced Master cohort

- "Acceptability of Maritime Projects": in order to help a group of stakeholders involved in a new maritime project to coordinate, the students drew up a booklet of key elements.
- "Multiuse Offshore Port": a sustainable design for platforms based on the case of a logistics terminal installed off the Breton coast.
- As an alternative to road haulage, in an environmentally-friendly approach, a "sea thoroughfare" linked the ports of Montoir de Bretagne and Gijon in Spain and saw several periods of activity between 2003 and 2014. The students carried out an appraisal, identified markets and calculated the breakeven point.

### Hydrographers and roboticists explore Guerlédan Lake

Hydrographers and roboticists are exploring Lake Guerlédan. This innovative R&D program is taking place over six months in semesters 3 and 5. It includes two weeks of intensive experiments on Guerlédan Lake, with the support of numerous partners. For the hydrographers, this completes the surveys carried out of Brest Roadstead, and for the roboticists, this provides a unique setting for practical work. The Guerlédan project enables theoretical knowledge to be applied, and new underwater observation technologies to be tested out with the help of cutting edge equipment, and through combining hydrography and autonomous robotics.

> + info. *List of subjects and partners:* [guerledan.ensta-bretagne.fr](http://guerledan.ensta-bretagne.fr)

### A mechanical engineering project for Thales

Thales has entrusted the 2<sup>nd</sup> year students (semester 3, 2021 cohort) with the design of a launch and recovery system of a towed sonar. 27 teams of 3 to 4 students created 27 different concepts and presented their digital models to Thales DMS. The 2 designs which were accepted will be the subject of a 2<sup>nd</sup> project at the beginning of 2020. This involves sizing these systems to ensure the feasibility of their manufacture.

### The ATMA Award for the best end-of-studies maritime project 2019

4 remarkable end-of-studies projects were honored by the ATMA (Aeronautics and Maritime Technology Association) during the award ceremony of 30 November 2019.

**The winner, Paul Antoine Grau** (mobile robotics profile) carried out his internship in a robotics startup in the Paris-Saclay (Kopadia) Incubator which develops innovative robotic technologies for the inspection of submarines and measurement of environmental impact. His subject was on the localization of underwater drones.

**Martin Bertin** (advanced mechanics profile) completed his internship at Gsea Design, which sizes the greatest names in competition sailboats. He developed a new tool which integrates the fatigue phenomena of composite materials.

**Éloïse Loussouarn** (offshore and naval architecture profile) carried out her co-operative (apprentice) engineer training and her end-of-year internship with Naval Group, where she developed a new cooling generator for submarines.

**Margot Remaud** (offshore and naval architecture) accomplished her internship in the Le Marin Research Center in the Netherlands, on digital simulation of the underway resistance of ships.

### Extra-curricular projects to develop know-how and soft skills<sup>1</sup>

ENSTA Bretagne is dedicated to supporting and highlighting the students' numerous extra-curricular projects. They cover many sports, technological challenges, leisure and also solidarity, citizen, humanitarian and cultural projects.

The list of associations and clubs is long and varied. It is enriched each year, as demonstrated by the latest initiatives created in 2019: Citoyens Solidaires, ENSTA'croisières, Quantum Computing, Cyber, Le Pouce d'Or, Chess Mates, ENSTA'astro, Kult'art.

> For a complete list: [www.ensta-bretagne.fr/fr/associations-et-clubs-etudiants](http://www.ensta-bretagne.fr/fr/associations-et-clubs-etudiants)

### Raphaëlle, President of the Bureau des Eleves (Students' Union) from May 2019 to April 2020

She is the first female military president of the ENSTA Bretagne Students' Union. Starting immediately in the month of August, the BDE set about welcoming the international students. Following on from that, it ran the induction weekend. Then, throughout the year, many events were organized: from a surfing trip to sustainable development initiatives

(mug detectors on the drinks machines, cleaning the beaches...), her team has had many innovative ideas. The BDE also forms a link between the school's administration and the students, especially when it comes to the prevention of all forms of inappropriate, violent or discriminatory behavior.

<sup>1</sup> behavioral skills



**59**  
CLUBS  
AND STUDENT  
ASSOCIATIONS



# TALENTS AND AWARDS



sport



technology



Spirit of Adventure



Sustainable Development and Social Responsibility



School

1<sup>st</sup> in the **French Universities Match Racing Sailing Championships**, in Antibes  
*(Photo of Kim Goetz and his team).*

> From 24 to 26 May



## High level sportsmen and women of the Pôle France Voile and talented engineers!

- Colombe, with her partner on the 470 sailing dinghy: bronze medal in the Europe Espoir and silver medal winner in the French cup.
- Lola, with her team on the Diam 24: 2<sup>nd</sup> in the sailing Tour de France and runner-up at the world match racing championships.
- Oël, windsurfing: 21<sup>st</sup> at the world championships and 4<sup>th</sup> in the French championships.



## EDHEC Sailing Cup:

1<sup>st</sup> in J80 , 2<sup>nd</sup> in First 31.7.

> from 17 to 25 April



## Noémie received the Rotary and Conférence des Grandes Écoles Award for Professional Ethics

for her essay "Ethical issues caused by fossil raw material extraction: the example of underwater mineral resources."

> 25 may

3<sup>rd</sup> place in the "ERL Emergency" international autonomous robotics competition in Seville, which combines land and air robot challenges.

> From 18 to 23 February



## 11 medals at the TSGED (Graduate Defense Schools Sports Tournament) which brings together 1 500 competitors from 12 graduate schools:

- Gold in sailing (for the 6<sup>th</sup> year running), women's and men's volleyball, men's football.
- Silver for men's handball and basketball, women's 50m freestyle and badminton.
- Bronze for women's basketball, fencing and 100m freestyle.





**Hydrocontest Competition:**  
3<sup>rd</sup> place in the "long distance" race, which tests the efficiency of ship prototypes.  
> From 2 to 8 september



ENSTA Bretagne awarded the highest level of the "**Bienvenue en France**" label by Campus France.  
> october



1<sup>st</sup> place in the "**Break the Code**" Challenge in Brest, organized by the Sopra Steria.  
> december

Théophile, co-operative (apprentice) engineer with the CNRS LOCEAN Laboratory, selected to spend a year on the Kerguelen Islands with the Paul-Emile Victor Polar (IPEV) Institute.  
> july



**4<sup>th</sup> in the Océan Hackathon:** Coline, first year student, one of the SMAUG team which won first prize in Brest.  
> october



**Lords of the ocean:** two former students tell us about their year of sailing and diving to encounter great white sharks.  
[bit.ly/LordsOcean](https://bit.ly/LordsOcean)  
> 17 september



**Naval architects, sailors and competitors: they took part in the Minitransat (trans-Atlantic race):** Kevin Bloch finished in 17<sup>th</sup> place on the ENSTA Bretagne boat and 3 former students were also well-placed (10<sup>th</sup>, 19<sup>th</sup> and 35<sup>th</sup>).  
> november



# ENSTARTUPS, ENSTA-BRETAGNE'S INCUBATOR



## CONTACT

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& ENSTARTUPS  
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Five companies created in the ENSTARTUPS incubator  
in 2019: hosted in the idea stage, they are now up and running!

Created in 2017, the ENSTARTUPS incubator aims to help people with projects in the idea stage by advising them through all the stages in company creation. It is continuing to develop and receive new projects. Five of them have gone from projects to companies: Fil&Fab, Umoja, Gwilen, Trash Surfboard, and Orphie.

The creation phase is the deciding moment for these entrepreneurs. We validate all the stages beforehand, so that the creation and rest of the adventure can continue in the best of all possible conditions. At the same time, failure or abandonment are also part of the life of a startup project. Two projects decided to give up on their entrepreneurial adventures due to failure to find a market.

## START-UPS CREATED

- **Fil&Fab:** "upcycling fishing nets"; their production lines have been set up.
  - **Umoja:** "shoes in African fabric"; open on the B2B market. [www.umoja-shoes.com](http://www.umoja-shoes.com)
  - **Gwilen:** "upcycling marine sediments"; creation of the structure and first orders forecast in 2020.
  - **Orphie:** "improving underwater camera vision"; prototype finished, seeking an industry to test it.
  - **Trash Surfboards :** "surfboards based on recycled cardboard"; creation of the structure.
- ▶ <http://bit.ly/Trash-Surfboards>

## EXAMPLES OF PROJECTS IN THE PROCESS OF INCUBATION

- **Ianira:** "autonomous diving robot"; in the prototype phase validated by the school, aiming to launch it on the market in 2020.
- **Niroji:** "original jewelry boxes"; in the strategy and positioning stage.
- **Subseastem:** "the abracadabra of fish"; integration of the project by a Brest SME, Cervall, and internal development underway.
- **Splashelec,** two projects: "make sailing accessible to a beginner" (sailing via a joystick) and "foil actuation project".
- **3D aluminum printing ≈:** market survey underway and creation of a business plan.

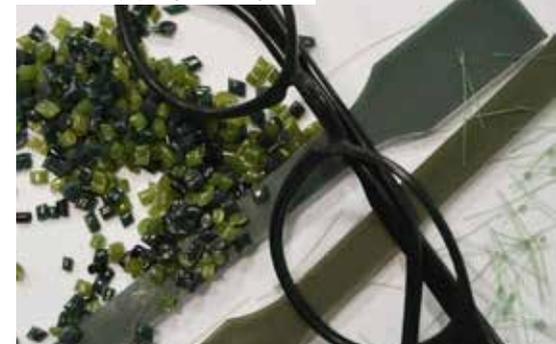
The Umoja range for sale at the Capucins in Brest (December 2019).



The Gwilen startup wins an award at the West Web Awards (January 2020).



Fil&Fab markets a new material made from upcycling old fishing nets.



11  
START-UPS  
IN CREATION in 2019

5  
COMPANIES  
CREATED in 2019

# RAISING STUDENT AWARENESS OF ENTREPRENEURSHIP



Before wanting to create a company, you need to want to become an entrepreneur. The training at ENSTA Bretagne takes place over 3 years and enables this passion for entrepreneurship to be passed on to our students in a progressive way.

## In the first year, all the students receive awareness training

- A conference breaks down all the myths surrounding entrepreneurship. It is delivered by the Technopole Brest Iroise in the presence of entrepreneurs from ENSTA Bretagne's incubator, and discussions rapidly ensue.
- From the 1<sup>st</sup> semester onwards, the students can also opt to take their first steps in entrepreneurship by choosing startup issues in the "bibliographic writing" project.

## In the 2<sup>nd</sup> year, volunteers can experiment with entrepreneurship

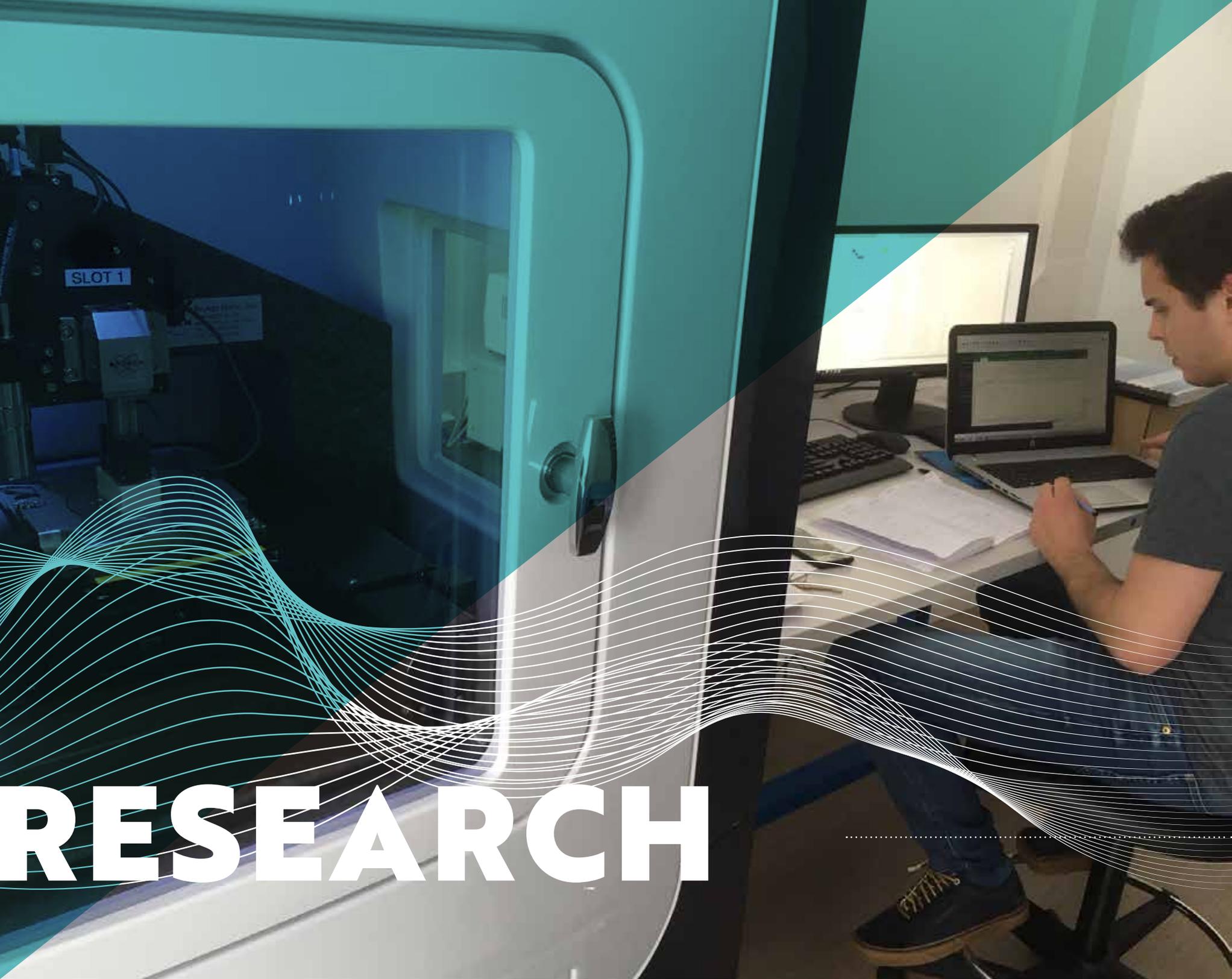
- They can take part in the regional then national Entrepreneuriales competition. 2 teams from ENSTA Bretagne competed in 2019.
- A company creation seminar has been started in partnership with The Corner, and takes place within this private incubator, revealing another environment to the students with its atypical premises. During the 3 days of training, the students have to solve an issue through validating the need and rapidly prototyping a solution (either hardware or software). 35 students took advantage.

## Implementation possible in the 3<sup>rd</sup> year

- The students who specialize in "Business Sciences" can follow the "Entrepreneurship" option and work on their own company creation project. About sixty hours of mentoring from external contributors covers all the aspects of the business plan, so that it can be drawn up and presented to bankers and investors. 9 ENSTA Bretagne student engineers enrolled on this course in 2019, together with 10 PhD students from ENSTA Bretagne and other establishments.
- The students can also continue to develop their companies on their internship, in semester 6, within the framework of their End-of-Studies Project, and aim to join an incubator such as ENSTARTUPS at ENSTA Bretagne.

## FOCUS

In October 2019, ENSTARTUPS hosted the innovation seminar, organized by the Club des Jeunes Dirigeants, on ENSTA Bretagne's campus. About sixty company heads came along to discuss with the incubator startups and the students with potential projects. Other contributors in the field of innovation also participated. This event was jointly organized with the ENSTA Bretagne "BEST" student association [Board of European Students of Technology].



# RESEARCH

# RESEARCH

The research activities led at ENSTA Bretagne are in response to concrete military and civilian issues and questions asked by industries or the DGA.

The development of structured relations with the major historic industrial partners, Naval Group and Thales, continued in 2019: the renewal or creation of joint laboratories with Naval Group, Gustave Zédé [dedicated to the sizing methods of marine structures] and SENI [dedicated to the naval embedded intelligence systems]; the creation and launch of the TRANNUM chair, in partnership with Thales DMS, and including ISEN Yncréa Ouest, dedicated to the use of digital technologies for the security of maritime spaces. Finally, ENSTA Bretagne has joined the naval systems cyberdefense chair, led by the Ecole Navale, IMT Atlantique, Naval Group and Thales.

The school's research institute has expanded: a 1,600 m<sup>2</sup> building dedicated to the activities in mechanical sciences of the Institut de Recherche Dupuy de Lôme (IRDLD) [Dupuy de Lôme Research Institute], has been built, and the building containing the cybersecurity activities has been refurbished. These constructions are part of the Plan Etat Région [state regional development plan] [CPER] 2015-2020 and thus house the new experimental facilities belonging to 5 investment programs [EcoSYsMer, CyberSSI, SMDMar, IROMI, Sophie], financed by the Breton territorial community, the French Ministry of Armed Forces and the European Union.

**116**  
**THESES**  
**IN PROGRESS,**  
**DEFENDED**  
**AND STARTED**

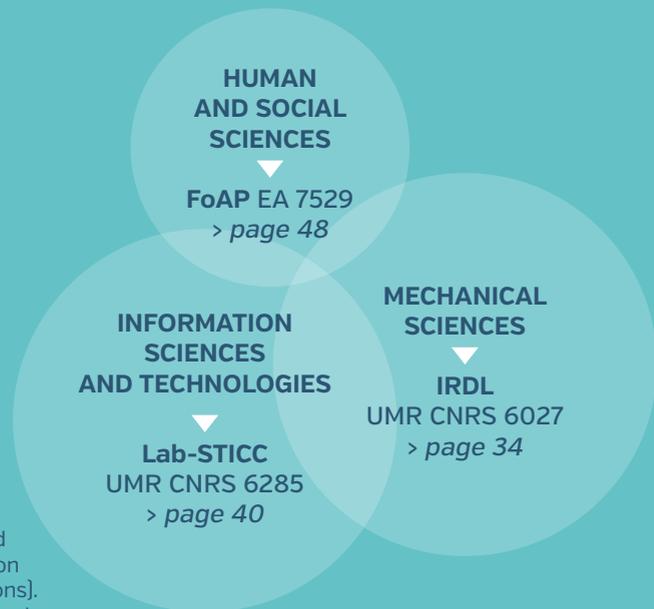
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**CONTRACTS WORTH**  
**9,95 M€**  
**NOTIFIED IN 2019**

The year has again shown a healthy level of contracts and scientific production [through publications]. The attractiveness and reputation of the school are continuing to grow as demonstrated by the great quality of the new in-take of research professors this year.

Finally, the research activities in human sciences have reached a major landmark this year with the birth of the new "Professional Apprenticeship and Training" research unit in January 2019 under the supervision of the CNAM Paris, AgroSup Dijon and ENSTA Bretagne. One of our professors has been entrusted with its management. In this field, the school has been involved in projects on an international scale, training engineers and innovators who are responsible and aware of major societal challenges.

Our socio-economic environment and the local and regional areas can rely on the numerous fields of expertise of ENSTA Bretagne to prepare the industrial and technological infrastructure of tomorrow, in particular in the field of marine sciences and technologies. The school is contributing to the 70.8 permanent exhibition at the Capucins, and will be its ambassador to a wide public audience.



**228**  
**RESEARCH STAFF**  
**AND DOCTORAL STUDENTS**



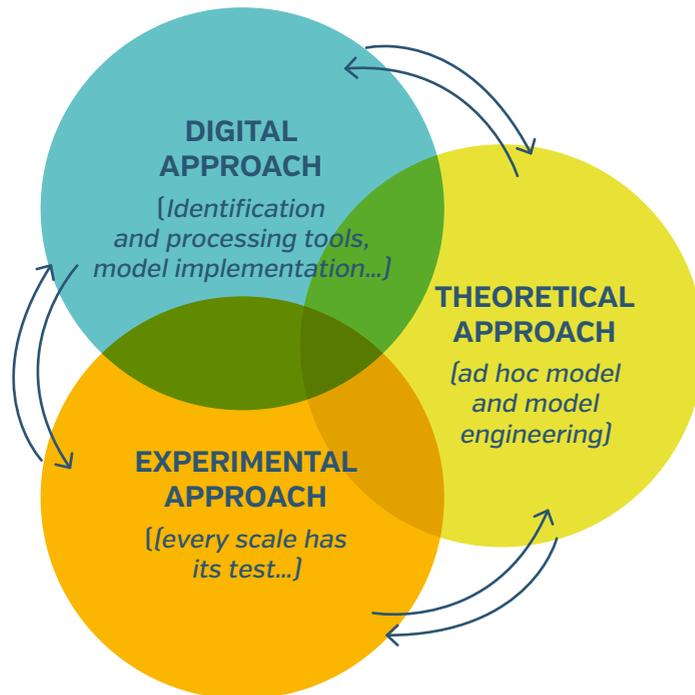
**Yann Dautreleau**  
 Scientific Director

Mechanical  
Sciences  
UMR 6027

# IRDL JOINT RESEARCH UNIT (UMR CNRS 6027)

## PROFILE

- Created on 1 January 2016, the IRDL is a mechanical science laboratory of scientific excellence and international and national renown.
- The result of the merger of well-known laboratories, it unites the research teams of 2 universities and 2 graduate schools : UBS, UBO, ENSTA Bretagne and ENIB.
- It is a CNRS joint research unit (UMR 6027), belonging to the INSIS.
- **260** members, including 120 doctoral students.
- Approximately **200** publications in peer-reviewed international journals/year.
- **The leading Breton laboratory in terms of proportion and volume of industry-linked theses** (cf. DRRT Report 2018: 30% of doctoral students under a CIFRE2 contract with a company).
-  [irdl.fr](http://irdl.fr)



ENSTA Bretagne  
is the 2<sup>nd</sup> most prolific  
contributor to the IRDL. "



**24**  
PEER-REVIEWED  
PUBLICATIONS



**48**  
THESES SUPERVISED



**4,2 M€**  
NOTIFIED  
CONTRACTS

*(IRDL figures/ ENSTA Bretagne site)*

## IRDL SCIENTIFIC PROJECT

### Materials and Mechanical Systems Engineering.

The IRDL is appreciated for its ambitious and original scientific project, the good balance between its preliminary and applied studies, the numerous interactions with companies and the quality of its training through research.

The UMR is organized in **5 Key Research Clusters**:

- PTR1 : Composites, nanocomposites, biocomposites.
- PTR2 : Multi-Material Assemblies.
- PTR3 : Structures, Fluids and Interactions.
- PTR4 : Energetic Systems and Thermal Processes.
- PTR5 : Behavior and Durability of Heterogeneous Materials.

ENSTA Bretagne mainly contributes to clusters 2, 3 and 5 and to a lesser extent, to cluster 1.

**3 transversal axes**, each attached to an industrial sector, are favored and confer upon the IRDL its unique position in France.

- SEA : offshore, naval construction, MREs.
- TRANSPORT : automobile, aeronautics
- DEFENSE : naval, land.

## CONTACT

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**The Association Française de Mécanique praised the quality of the organization of the 2019 CFM, its impressive program, the originality of its maritime themed sessions, the quality of the reception by the Brest teams and the great success in terms of participation, which made it one of the best ever editions that the CFM had ever seen "**

Read the full article  
[www.campusmer.fr/Actualités-3249-51-0-0.html](http://www.campusmer.fr/Actualités-3249-51-0-0.html)



## MEMORABLE MOMENTS OF 2019

### BREST HOSTS THE FRENCH CONGRESS ON MECHANICS IN AUGUST 2019

The IRDL was chosen by the Association Française de Mécanique (AFM) to organize the 24<sup>TH</sup> edition of the Congrès Français de Mécanique or French Congress on Mechanics, from 26 to 30 August. Several thousand researchers and scientists met in Brest for this much awaited Biennial.

Juliette Rimetz from Campus Mondial de la Mer was there and tells us about it...

#### Covering all aspects of mechanics and highlighting major innovations

The CFM is the occasion for keeping up-to-date with research on the mechanics of fluids and solids, mechanical, electronic and engineering applications in materials and even acoustics. "In each research field, there are major innovations" points out Sylvain Calloch, Deputy Director of the IRDL. For example, in the digital field, models are becoming more streamlined. "Computational power is increasing year on year but we have so many data, we do not know what to do with them", explains the researcher. "Model streamlining enables more accurate results to be obtained".

Another example is experimental mechanics: it produces field measurements using optical or infrared cameras. "That changes our way of conducting tests and processing the results", says Sylvain Calloch.

#### The sea as an application domain

As it took place in Brest, the congress was obviously going to cover the marine world, with subjects examining renewable marine energies, the naval and nautical sectors (including sail propulsion and hydrofoils), ocean hydrodynamics, underwater robotics etc.

"Corrosion leading to early structural aging is one of the specific features of the marine world" explains Sylvain Calloch. "Building a race boat requires the use of high-performance composites, the behavior of which needs to be studied. In shipbuilding, you need to take into account the service life of the vessels (about 40 years) and use all possible means to reduce the maintenance costs and ensure the service life. And all of that is on an case-by-case basis, as the boats are not built in series like a car".

The congress participants, most of whom do not work in the maritime sector, were informed of the theme through plenary and semi-plenary sessions, including, for example,

Naval Group, the Musée National de la Marine, and the GSea Design company from Lorient on the "Design and Sizing of Competition Sailboats".

The theme of renewable marine energies was also covered in depth, especially by France Energies Marines. During a semi-plenary session, Jean-François Filipot, Scientific and Technical Director, presented the breaking wave measurement campaign on the Jument Lighthouse, off Ushant Island. The aim of such a study: evaluate the impact of giant waves on maritime structures such as wind turbines. Jean-François Filipot then led a session dedicated to mechanics for renewable energies. As for Antoine Maison structural calculations engineer (ENSTA Bretagne 2015 graduate), he presented a study on the modeling of seafloor marine turbine electric cable stability in areas of strong currents.

#### A French congress with an international dimension

There was an international dimension to the congress as demonstrated by the delegates who came from 16 different countries. Moreover, the CFM hosted the associated event EuroMech, organized by the European Mechanics Society, a society which brings together European specialists in mechanics. Presided over by Peter Davies of Ifremer, this symposium was dedicated to the aging of polymers in the marine environment.

The CFM was also the occasion for the IRDL to discuss the European RAMSSES Project. This project brings together 37 partners (including the IRDL/ENSTA Bretagne) over the concept of future ship design. The IRDL is also in charge of the following subjects: propulsion systems/propellers and the assembly of composite superstructures on metal parts.

The Extremely Large Telescope



# assembling # bonding # welding  
 # sintering # additive manufacturing  
 # multi-materials

25 STAFF including  
 8 DOCTORAL STUDENTS

7 PUBLICATIONS  
 in peer-reviewed  
 journals

## FOCUS

### ADHESIVE BEHAVIOR FOR THE DESIGN OF THE ELT (EXTREMELY LARGE TELESCOPE)

Built in Northern Chili by ESO (the European Southern Observatory) in partnership with Safran Reosc, the ELT is on an exceptional order of magnitude. Thanks to its main, 39m wide mirror and its ideal location (3060m altitude in the Central Andes) it will be able

to gather 15 times more light than the current VLT (Very Large Telescope) enabling stellar archaeology and the search for far away exoplanets. Safran Reosc started work on a thesis in 2016 in order to understand the influence on tempera-

ture on the structural adhesive behavior. After 3 years of work, many macroscopic and microscopic phenomena were revealed and helped the engineers at Safran Reosc in their design and sizing stage.

# MULTI-MATERIAL ASSEMBLIES

(PTR2)

## KEY RESEARCH THEMES

The aims of the IDRL research cluster "Multi-Material Assemblies" are the innovation of assemblies, the characterization of their long-term durability in extreme environments and the development of hybrid techniques.

- Studying and optimizing assembly procedures by assembling different types of materials, treated with new surface preparations.
- Examining assemblies throughout, using instrumentation (FGB, QRS, CIN...) and original experimental initiatives
- Developing sizing tools for adhesively-bonded assemblies including the parameters associated with bonding procedures.
- Characterizing the performance of assemblies in harsh environments over the long term.
- Developing hybrid techniques (weld bonding etc) for multi-material structures to obtain high performance material characteristics.

## RESEARCH PROGRAMS

- Simplified modeling of a SCARF joint test in order to characterize the mechanics of adhesively-bonded assemblies (financed by the Regional Council of Brittany – Région Bretagne.)
- Development of a multi-material structural bonded assembly providing ballistic protection (financed by the DGA, with 2CA).
- Development of technological testing to validate the behavior modeling of impact effects on an adhesive (financed by SAFRAN Composites).
- Durability of structural adhesives used in applications for space optics in thermal environments (with SAFRAN Reosc).
- Analytical and digital modeling of the lateral buckling of offshore pipes (financed by the Regional Council of Brittany – Région Bretagne).

## 5 THESES BEGUN IN 2019

- **Amen BENALI** (Cifre ECM-BE): "Consideration of the influence of different structural adhesive procedures on the sizing method of adhesively-bonded assemblies".
- **Marthe LOISEAU** (financed by the DGA, Coldpad; with IFSTTAR): "Creep resistance under loading of adhesively-bonded fasteners for subsea applications".
- **Leandro MAURICIO DA SILVA** (Cifre PSA): "Mastering the differential expansion on the scale of a structurally bonded multi-material assembly body-in-white".
- **Cyril BERNOLIN** (financed by Safran Composites and the Regional Council of Brittany – Région Bretagne): "Crack propagation in adhesively-bonded assemblies subject to monotonic and cyclic loading for different mode combinations".
- **Paulo GUIMARES** (financed by the Nouvelle Aquitaine Regional Council – Région Nouvelle Aquitaine, with Nobatek INEF4): "Durability of high thickness bonding using high elongation adhesives. The mechanical and physico-chemical aspects".

## CONTACT

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## RESEARCH

# STRUCTURE, FLUIDS & INTERACTIONS

(PTR3)



## KEY RESEARCH THEMES

The research focuses on fluid-structure interactions, the dynamic behavior of materials and structures and detonics. The applications are for naval architectures, marine energies, defense, aerospace, automobiles as well as manufacturing processes.

- Naval hydrodynamics and the study of the response of structures in interaction with fluids.
- Characterization and modeling of the response of metallic and composite materials and structures subjected to dynamic loading.
- Study and modeling of impact phenomena and explosions in complex environments.

## RESEARCH PROGRAMS

- The Windkeeper program, to design a maintenance vessel for offshore windfarm turbines has finished. The work concerned the analysis of the hydrodynamic impacts of waves on the bridge.
- COMPADD : characterization of a composite assembly obtained by additive manufacturing under dynamic loading (with Mines ParisTech).
- Projet on supersonic projectile deceleration through liquid foam (financed by the DGA/AID; with the Institut de Physique de Rennes).
- The **SOLID SAIL** project is continuing. This innovative, 100% composite rigid sail of over 1000 m<sup>2</sup> created by the Chantiers de l'Atlantique, will propel the future largest sail cruise liner (Silenseas). The ENSTA Bretagne team is contributing to the sizing calculations and trials. It is bringing its expertise in fluid-structure interactions and non-linear simulations to model the constraints experienced by the sail panels and predict propulsive global stresses.

## 7 THESES DEFENDED IN 2019

- **Antoine MORVAN** [ADEME contract; with CNIM]: "Impact on the wet deck of a ship for offshore wind turbine maintenance" (Windkeeper project).
- **Julien ERCOLANELLI** [CIFRE GEPS Techno; with Ifremer] : "Numerical and experimental study of a dual wave energy stabilizer/recuperator system".
- **Gonzalo DOISENBAT** [Regional Council of Brittany – Région Bretagne contract, Ifremer]: "Digital and experimental modeling of offshore wind turbine energy harnessing".
- **Mourad NACHTANE** [Eiffel grant, with the Moroccan University of Hassan II, Casablanca]: "Marine turbine composite material performance studies".
- **Mohamed Chams Eddine EZZINE** [PROFAS B+ contract; with the Algerian University of Djillali Liabès]: "Damage and failure of hybrid assemblies: rivets-adhesives".
- **Youssef BELABED** [with the Algerian University of Aboubakr Belakaïd]: "Study and analysis of the delamination of structures reinforced by multilayer FRP composites".
- **Quentin RAIMBAUD** [DGA grant]: "Modeling and optimization of shock wave absorption by liquid foams, tests on a film scale and film series".

## FOCUS

### PROLONGING THE SERVICE LIFE OF OFFSHORE WIND TURBINE MOORING LINES

Two projects are in succession: Polyamoor and Monamoor (financed by ANR/France Energies Marines; with many partners). The use of woven nylon cables will bring a flexible

fastening suited to offshore wind turbines, that will last for 20 years. In addition to Ifremer's aging studies, ENSTA Bretagne has designed innovative tests over several months,

to characterize and model the behavior of these nylon lines. The 2<sup>nd</sup> project will enhance this model and enable the cables to be instrumented.



- # modeling # digital simulation
- # experimental mechanics
- # materials and structures
- # dynamics # shocks
- # impacts # structure-fluid interactions

36 STAFF including  
13 DOCTORAL  
STUDENTS

9 PUBLICATIONS  
in peer-reviewed journals

+ 12 DOCTORAL  
STUDENTS belonging  
to PTRI Composites



Fatigue tests on welded assemblies.



#fatigue #aging #fatigue  
 resistance #modeling #testing

27 STAFF including  
 15 DOCTORAL  
 STUDENTS

8 PUBLICATIONS  
 in peer-reviewed  
 journals

## BEHAVIOR AND DURABILITY OF HETEROGENEOUS MATERIALS (PTR5)

### KEY RESEARCH THEMES

Research focuses on the assessment, measurement, modeling and prediction of the integrity of materials, structures and electromechanical systems.

- Fatigue and self-heating of materials and structures (metals, composites and organic materials)
- Behavior and fatigue of active materials (piezoelectric or memory-shape materials)
- Thermal and marine aging of organic materials.
- Non-linear behavior of heterogeneous materials.

While answering fundamental scientific questions, this applied research is led with European industries in many sectors, in particular the automobile, aeronautical, and energy sectors, and material suppliers.

### RESEARCH PROGRAMS

- Load spectrums for the mechanical sizing of an automotive vehicle (financed by the PSA Group)
- The fatigue life of high cycle naval application drive shafts subject to variable and multiaxial loading (financed by Naval Group).
- A simplified approach for complex cyclic loading fatigue life calculation in a confined plastic zone (financed by DGA).
- Fatigue in short fiber (3D woven) thermoplastic composites for aeronautical applications subject to complex pressure loading: behavior law and sizing criteria (financed by SAFRAN).
- Thermomechanical investigation for the fatigue sizing of parts designed in different materials: polyurethane foams and glass fiber thermoplastics, or elastomers.

### 2 THESES DEFENDED IN 2019

- **Julien LOUGE** (financed by CIFRE Arcelor Mittal): *"The contribution of the measurement of self-heating to the study of steel fatigue: history and pure shearing effects"*.
- **Thomas GLANOVSKI** (financed by CIFRE Trelleborg): *"Comprehension and modeling of elementary fatigue damage mechanisms of natural rubber"*.

### FOCUS

#### VINCENT LE SAUX HAS OBTAINED HIS HDR

ENSTA Bretagne engineer and doctor, Vincent has obtained his **Habilitation à Diriger des Recherches**. (Accreditation to Supervise Research). His work is on the mechanical behavior and durability of polymer materials. For 10 years in the IRDL, he has characterized and modeled polymer materials (elas-

tomers, short fiber thermoplastics, 3D woven composites, polyurethane foams) for the automobile and aeronautics industries. The aim is to obtain a better understanding of the materials and their properties, especially in terms of fatigue, to improve the sizing tools whilst adding certain important ad-

ditional effects (for example, their interaction with the environment or the manufacturing process). These results enable the partners to answer new societal issues, such as minimizing and reducing environmental impacts.

## CONTACT

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## RESEARCH

# GUSTAVE ZÉDÉ JOINT LABORATORY

(NAVAL GROUP, ENSTA BRETAGNE)

## KEY RESEARCH THEMES

**This joint R&D initiative enables the development of innovative tools to assist in the sizing of naval structures subject to extreme loading.**

The teams conduct experimental research and model the issues concerning the resistance and durability of the material used in the military naval industry.

## 2 KEY SCIENTIFIC THEMES

- The characterization of the fatigue resistance of material and assemblies for naval structures.
- The establishment of digital chains to help size naval structures, taking into consideration manufacturing method effects and effective loading.

## MAJOR PROJECTS

- **H2020 RAMSSES European project:** for cleaner and more efficient ships. 37 partners in 11 countries contribute to the 13 fields of innovation which this project covers. The different components complement each other in reducing the environmental footprint of ships. As for the aeronautical and automotive sectors, this reduction is one of the challenges. For this theme, the ENSTA Bretagne team/Naval Group team is in charge of the durability of the adhesively-bonded joints between a composite and a metallic structure. This also includes establishing a high cycle fatigue sizing computational support chain for steel propellers, obtained by additive manufacturing. These models will be validated by full scale testing.

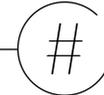
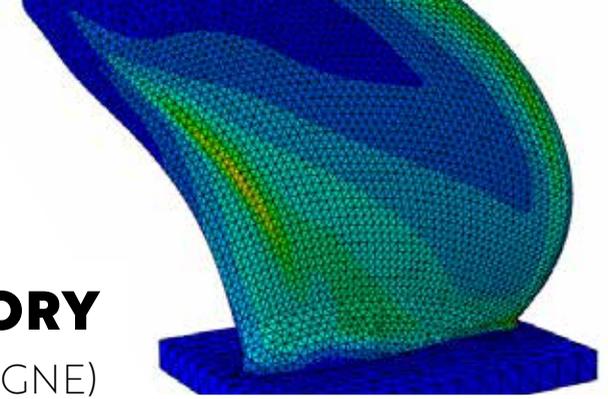
- **EA FRAPAN project (2018 – 2020):** on the characterization and modeling of the fatigue resistance of parts for naval vessels, obtained by additive manufacturing such as WAAM (Wire Arc Additive Manufacturing). It focuses on improving the comprehension of the link between heterogeneity of the microstructuring resulting from such a manufacturing process and the part's fatigue properties. EA INCOLA project (2020–2022). This focuses on the multi-axial fatigue of propeller shafts. The objective of this thesis is the rapid characterization of the fatigue properties of the metallic materials used.
- **A final year project (2020)** will focus on the rapid characterization of the fatigue properties of composite materials.
- **EA AMERICICO project** (Improvement of study methods for constructing and industrializing submarine hulls) (2020-2021). Two key themes are examined: shaping and fatigue resistance. The aim is to predict the structure and assembly fatigue (with welded or adhesively-bonded joints) of naval structures taking into account the effects linked to manufacturing processes and the changes in effective loading. The prediction of the mechanical resistance of the naval structures extends to other forms of destruction such as impacts or buckling.

## FOCUS

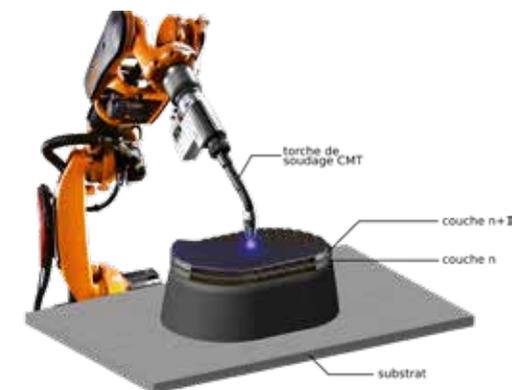
For the last four years, this organization has provided a framework for the programs led by Naval Group and ENSTA Bretagne, and their rapid transfer to the study offices of Naval Group.

The research also interacts through the training of engineers via the implementation of supervised application projects and internships

In November 2019, this joint laboratory was extended in the presence of Hervé Guillou, Chairman and CEO of Naval Group.



# added value # transfer  
# modeling # characterization  
# fatigue # materials # assemblies  
# additive manufacturing # steel  
# composites # naval



Knowledge, Information  
and Communication  
Science and Technology  
Laboratory  
UMR 6285

# LAB-STICC

## JOINT RESEARCH UNIT

### PROFILE

- The Lab-STICC laboratory is a multidisciplinary center of excellence, created in 2008.
- Jointly supervised by the CNRS and 5 Breton establishments, it unites research teams in information and communication sciences and technologies in 3 graduate engineering schools and 2 universities: IMT Atlantique, ENSTA Bretagne, ENIB, UBO and UBS.
- CNRS Joint Research Unit 6285, the laboratory is attached to the INS21 as its main institute and the INSIS as its second institute.
- **566** staff, including 206 doctoral students.
- Approximately **450** publications /year.
-  [www.labsticc.fr](http://www.labsticc.fr)



ENSTA Bretagne is the  
**3<sup>rd</sup> most prolific**  
contributor to the Lab-STICC

Lab-STICC / ENSTA Bretagne key figures

  
**104**  
PUBLICATIONS

  
**55**  
SUPERVISED THESES

  
**5,8 M€**  
NOTIFIED CONTRACTS

### THE LAB-STICC SCIENTIFIC PROJECT

#### From sensors to knowledge : communicate and decide.

Fundamental and applied research unit, with a high level of interactivity with its socio-economic environment, the Lab-STICC is a fount of multiple extremely high level skills concerning digital and communicating systems. Its excellence and high rate of scientific output are the keys to its solid, international reputation.

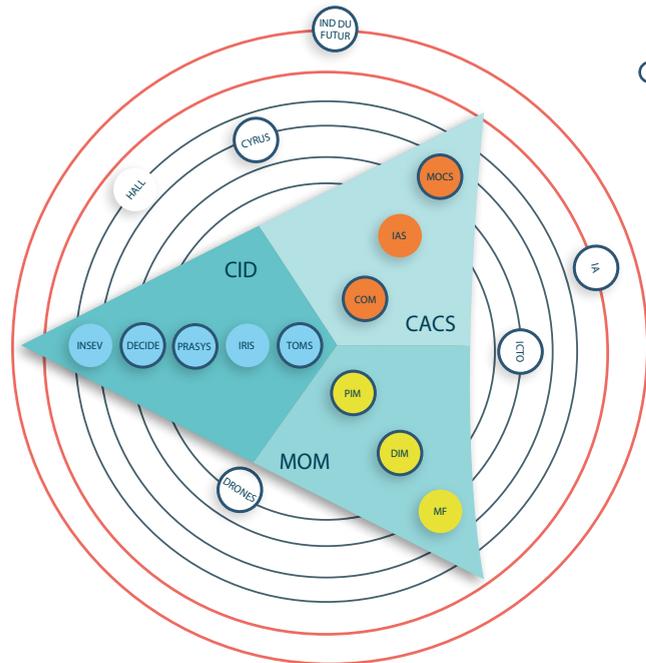
The laboratory is organized in 11 teams, divided into 3 scientific departments, to which ENSTA Bretagne is a contributor:

- MOM : Microwaves, Optoelectronics and Materials.
- CACS : Communication, Architecture, Circuits and Systems.
- CID : Knowledge, Information, Decision.

Further to these disciplinary divisions, transversal programs answer highly interdisciplinary societal challenges such as :

- Assistance devices for the dependent
- Cybersecurity and cyberdefense
- ICST and the sea
- New information representation and processing methods for artificial intelligence.
- Drone systems

## ○ THE MAIN SCIENTIFIC TEAMS INVOLVING ENSTA BRETAGNE



### ○ THE ENSTA BRETAGNE TEAMS

Covering **3 scientific poles** of the Lab-STICC. Contributes to **6 of the 11** scientific teams and **5 of the 6 transversal fields**. **Heavily involved** with the socio-economic environment.

#### IN THE CID POLE (KNOWLEDGE, INFORMATION, DECISION)

**TOMS** : Processing, Observation and Statistical Methods  
*[cf. page 42]*

**PRASYS** : Perception, Robotics Autonomous Systems  
*[cf. page 43]*

#### IN THE CACS POLE (COMMUNICATION, ARCHITECTURE, CIRCUITS AND SYSTEMS)

**COM** : Digital COMMunication  
*[cf. page 44]*

**MOCS** : Methods, Tools for design of Architecture and Circuits  
*[cf. page 45]*

#### IN THE MOM POLE (MICROWAVES, OPTOELECTRONICS AND MATERIALS)

**PIM** : Multi-scale Propagation and Interaction  
*[cf. page 46]*

## INDUSTRIAL CHAIRS AND JOINT LABORATORIES

### LATERAL Lab-com with THALES TOSA

on technologies for microwave, antenna and guidance devices for embedded systems.

### WAVES Lab-com with THALES DMS

on improving autonomous and distributed sensor network performance for detection and automatic identification in the marine environment.

### APRIL 2019 Creation of the TRANSNUM Chair with THALES

The chair includes Thales DMS, ENSTA Bretagne and ISEN Brest. Its aim is to develop new autonomous observation and surveillance systems for the marine environment. The school brings its recognized knowledge in marine robotics and sensor networks.

### NOVEMBER 2019 Creation of the SENI Lab-com with NAVAL GROUP

This joint laboratory aims to design intelligent naval embedded systems, that acquire information on the environment and vessel function, and to implement decision and action processes on board.

### DECEMBER 2019 ENSTA Bretagne joins the naval systems Cyberdefense chair

With the support of the Marine Nationale [French Navy], the Regional Council of Brittany and the Cyber Center of Excellence, the chair aims to protect digital equipment and detect cyber attacks in maritime systems.

10 theses have been undertaken, supervised by the 5 partners (École Navale, IMT Atlantique, Naval Group, Thales, and ENSTA Bretagne).

# PROCESSING, OBSERVATION AND STATISTICAL METHODS

(TOMS TEAM)

## KEY RESEARCH THEMES

The Lab-STICC contributes to the methodological and practical aspects of signal and image data processing, in underwater and air environments.

- Development of estimation methods, statistical detection and acoustic and electromagnetic signal representation.
- Monitoring of the underwater environment : localization of acoustic sources, characterization of the environment, the nature and evolution of the depths, detection and recognition of objects, bathymetry, halieutic resource studies.
- Spaceborne and airborne remote sensing: space-time estimation of geophysical fields and ecological dynamics; object detection and recognition [ships, planes etc]; surveillance of zones of interest [pollution etc].

## FOCUS

### INTERNATIONAL COOPERATION IN BIOACOUSTICS

Passive acoustic devices are deployed to follow whale populations, in particular in the south west Indian Ocean. Kate Stafford (University of Washington, in Seattle) has been following them since 2008. She has just received a PhD student from the team to interpret data.

Another example is with the University of Concepción, in Chile, deploying acoustic transponders in other ocean zones, especially off the coast of Chile. These ties became even closer during the World Marine Mammal Conference [Barcelona, Dec. 2019].

## RESEARCH PROGRAMS

### > IN SIGNAL PROCESSING

- Financed by the DGA : acoustic data processing to characterize the marine environment ; study of physical quantities relevant for machine learning in underwater acoustics and fluctuating environments; detection and recognition of multiple objects on diverse floors through deep learning (with IRISA, UBO, UMR AMURE, MBDA).
- AID financed deep learning methods : scalable techniques for target detection and recognition using heterogeneous data; physics-guided probabilistic deep learning for underwater acoustics.
- European Regional Development Fund : digital analysis of drone data.

### > IN BIOACOUSTICS & ENVIRONMENTAL STUDIES

- Contract with the Biodiversity Agency for the passive acoustic surveillance of cetaceans in the second volume of the Marine Strategy Framework Directive (MSFD) established by the members of the European Union).
- OSMOSE (Open Science Meets Ocean Sounds Explorer) : collaborative underwater acoustics project for ocean observation (with IMT Atlantique, IUEM, Woods Hole Oceanographic Institution).

## 1 THESIS DEFENDED IN 2019

- **Juan Luis ROSENDRO** [Eiffel grant, jointly supervised by the University of La Plata, Argentina]: "Robust techniques for the automatic control of robotic systems".

Spectrogram : marine mammal acoustic signatures.



- # Marine environment
- # radar image [SAR/ISAR]
- # underwater bioacoustics
- # passive acoustics
- # machine learning
- # deep learning
- # data science
- # big data
- # target recognition
- # fusion
- # decision support

29 STAFF  
including 9 DOCTORAL  
STUDENTS

26 PUBLICATIONS  
in peer-reviewed  
journals

### APPLICATIONS

Underwater bioacoustics, the study and defense of environments (underwater acoustics and radar).

# PERCEPTION, ROBOTICS AND AUTONOMOUS SYSTEMS

(PRASYS TEAM)



Thomas Le Mezo Thesis.

## KEY RESEARCH THEMES

The development of algorithms for environment perception autonomous robots is based on the mastery of three components: perception, action and their interaction.

An autonomous perception system must simultaneously analyze the data acquired on its immediate environment and autonomously organize its mission, in terms of piloting and navigation. The interaction between the robot and its environment is accomplished by sensors.

### > RESEARCH THEME 1 « AUTONOMOUS ACTION »

By using the results from perception, the system must deduce the actions it requires to be able to accomplish its mission according to certain criteria such as efficiency, safety, speed and even energy consumption.

### > RESEARCH THEME 2 « AUTONOMOUS PERCEPTION »

The system endeavors to understand its observations and formulate an accurate representation not only of the state but also the uncertainty of its current environment.

## RESEARCH PROGRAMS

- NAVIDRO : development of a precise navigation simulator for autonomous underwater vehicles (financed by the SHOM).
- CHIMAERA : lasers, net detection and avoidance, underwater communication (financed by the DGA ; with OXXIUS, Thales, IMT Atlantique).
- Ident3D : 3D data processing to assist in mine identification (financed by the DGA TN Brest).
- BathySat : satellite bathymetry estimation using multispectral images (for Hytech Imaging).
- Physics-guided probabilistic deep learning for underwater acoustics (financed by DGA AID)

## 4 THESES DEFENDED IN 2019

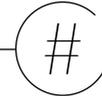
- **Thomas LE MEZO** (financed by DGA and the Brittany Regional Council – Région Bretagne) : cf.focus
- **Gaspard MINSTER** (financed by ANR) : « Modeling the salination process [sediment movement] in extreme environments. Application in the Raz Blanchard ».
- **Thibaut NICO** (CIFRE ECA Robotics) : « Study and development of underwater object relocation solutions using heterogeneous underwater vehicles ».
- **Vincent MYERS** (financed by Defence & Research Canada) : « Processing, interpretation and exploitation of SAR antenna sonar images obtained from repetitive trajectories ».

## FOCUS

### AUTONOMOUS ROBOTS IN SEA CURRENTS

In order to carry out lengthy missions over long distances, Thomas Le Mezo's thesis uses sea currents as the main means of propulsion. A new type of underwater robot has been developed (cf. photo) and validated at sea. New theoretical tools have

also been proposed. This is a major contribution to the validation of the safe use of cyber-physical systems. This work has been endorsed by many scientific publications in international journals (IEEE TAC, AMC, IJC).



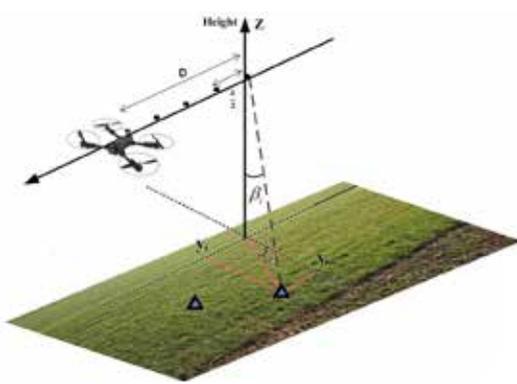
# Mobile robotics  
# autonomous system # localization  
# perception # control

**33 STAFF**  
including **18 DOCTORAL**  
**STUDENTS**

**33 ARTICLES**  
in peer-reviewed journals  
and conference  
proceedings + **2 books**

### APPLICATIONS

Defense and security,  
underwater archaeology,  
missions in hostile  
environments.



- # Blind source separation
- # higher order statistics
- # signal processing # robotics
- # telecommunications
- # electronic warfare # cognitive radio # biomedicine

**16 STAFF**  
 including 8 DOCTORAL  
 STUDENTS

**2 PUBLICATIONS**  
 in peer-reviewed journals  
 + 2 books and 1 chapter  
 in an edited volume

#### APPLICATIONS

Telecommunications, electronic warfare, robotics, embedded systems, the Internet of Things, biomedicine...

## DIGITAL COMMUNICATION

(COM TEAM)

### KEY RESEARCH THEMES

The team is interested in statistical methods and signal processing algorithms, focusing on antenna systems and the miniaturization of electronic circuits.

### FOCUS

#### MULTI-LAYER DIGITAL ANALOG SYSTEM FOR CYBERDEFENSE OR RADIO MONITORING

› StCyber Project ; financed by DGA ;  
 ensta-bretagne.fr/stcyber/

An attack on our communication systems would doubtless be extremely serious or even critical. Indeed, communication technologies and our communicating and intelligent machines are everywhere in everyday life. Means of communication (base stations, GPS, drones, sa-

tellites) can be subject to noise and radio interference and also the target of enemy attacks. This innovative project will enable efficient protection within a cyberdefense strategy, by improving our ability to ensure radio monitoring.

### RESEARCH PROGRAMS

#### > TELECOMMUNICATIONS

- Estimating communication channel characteristics for better broadcasting and information protection.
- Game theory for the development of protocols for tactical cognitive radio.
- Smart Antenna & Beamforming : the antenna must self-adapt to its environment
- The Internet of Things and wireless network issues related to the coexistence of machine-to-machine (M2M) and human-to-human (H2H) communications.

#### > MEDICAL APPLICATIONS (WITH THE HÔPITAL DES ARMÉES MILITARY HOSPITAL AND CHRU UNIVERSITY HOSPITAL OF BREST)

- The acquisition and processing of electrocardiograms of the foetus and its mother using wireless sensors.
- Characterization and classification of deep vein thrombosis (blood clots).
- The use of EEG [electroencephalographic] signals and EMG [electromyograms] for wheelchair control by the paraplegic..
- The use of EOG [electro-oculographic] signals for web page activation and surfing by the paralyzed: creation of an ECG sensor and simulator for the Faculty of Medicine.

### 2 NEW THESES IN 2019

- **Rida MORTADA** (financed by a Lebanese grant) :  
 « Energy harvesting in a cognitive radio ».
- **Marwa IBRAHIM** (financed by a Lebanese grant):  
 « Ecoenergetic strategies combined with Big Data analysis in wireless sensor networks ».

## CONTACT

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## RESEARCH



Projet Ker-Seveco.

# METHODS, TOOLS, CIRCUITS AND SYSTEMS (MOCS TEAM)

## KEY RESEARCH THEMES

Their key focus is software engineering methodologies. The applications are numerous : intelligent cities, connected houses, e-health, and defense. All of these require connected, embedded systems.

The focus on software is dominant, very heterogeneous due to the diverse equipment which interacts, and must offer secure use, secure communications and data protection. To that, we can add the many expectations of industry in terms of software : more rapid and secure design, easier development, the capacity to virtualize and simulate, the management of variables etc. The main scientific themes: heterogeneous model federation, formal verification techniques, securing compilation flow for reconfigurable circuits, the virtualization of reconfigurable architectures for sustainable and secure system on chip (SoC) design, variability management for product line design.

## RESEARCH PROGRAMS

- EASE4SE (completed in 2019) : the federation of executable models for the operational simulation of defense systems.
- VeriMoB (continuing in 2020 with PragmaDev) : execution and formal verification of system to system models described using NAF (NATO Architecture Framework). The PRO-CESS tool has been developed and integrates the formal verification engine OBP2[www.obpcdl.org].
- Securing overlay architectures for the long-term operational maintenance of digital circuits in operational condition (continues in 2020)
- JoinSafeCyber : designing a design and analysis framework enabling critical system modeling and refinement taking into account both the relative reliability and Cyber Security requirements.

## 1 THESIS DEFENDED IN 2019

- **Vincent LEILDE** (financed by the Brittany Regional Council - Région Bretagne): « Formal system verification diagnostic support ». This thesis was led within the framework of the DEPARTS (Design Patterns for Real-Time and Safe applications) project, financed from 2013 to 2018 by the future investments program on « Briques Génériques du Logiciel Embarqué » [Embedded Software Generic Blocks].

## 3 NEW THESES IN 2019

- **Emilien FOURNIER** (financed by the Pôle d'Excellence Cyber and the Brittany Regional Council - Région Bretagne): « Threat anticipation during critical system execution ».
- **Grégoire DE BROGLIE** (finance by DGA) : « Furtive communication via software radio with airborne drones in a cognitive radio context ».
- **Maelic LOUART** (financed by the Brittany Regional Council -Région Bretagne; the Cyber-Naval Chair) : « Automatic real time detection of AIS tampering ».

## FOCUS

### KER-SEVECO

A new project which aims to develop products and services integrated in connected vehicles, as well as the associated external services. These services embedded in the vehicle will have followed a secure development process. ENSTA Bretagne is involved in the development of a design

methodology and a specially-designed cybersecurity test toolkit for "connected vehicles". This methodology must encompass the system, integrating security requirements, through to the communication modules of the embedded computer. The expected outcome of the project will be the development of new

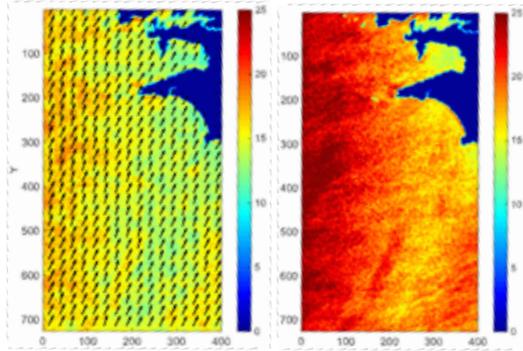
mobility services such as fleet management, the development of a Cyberlab to ensure service security testing and a methodological formal security requirement based package. 3 partners: KEREVAL, Mobility Tech Green and ENSTA Bretagne.



# safety # security # embedded systems # system design # circuit virtualization # model federation # formal verification

16 STAFF  
including 10 DOCTORAL STUDENTS

22 ARTICLES  
in publications  
and international  
conference proceedings



Wind fields estimated using satellite radar images.



# Sensors # radar # GNSS  
 # GE # propagation channel  
 # clutter # electromagnetic modeling  
 # target signature # environment  
 # remote sensing # inversion # experiment

**15 STAFF**  
 including **8 DOCTORAL STUDENTS**

**14 PUBLICATIONS**  
 in peer-reviewed journals and international conference proceedings

### APPLICATIONS

Radar : electronic warfare ; geolocalization and navigation ; marine pollution ; surveillance ; maritime safety and security : microwave remote sensing ; target detection/reconnaissance and tracking [using radar images/signals].

# MULTI-SCALE INTERACTIONS AND PROPAGATION

(PIM TEAM)

## KEY RESEARCH THEMES

**This research aims to integrate more artificial intelligence in acquisition and exploitation systems for radar type observations (airborne or satellite) or GPS type geolocalization.**

The teams orient its research towards the development and improvement of modeling and optimization tools for the representation and comprehension support of phenomena generated by the interaction of electromagnetic waves with the environment. These phenomena are observed on different scales.

- Modeling and multi-physical, multi-scale electromagnetic simulation
- Propagation and interaction of waves with the environment (sea, atmosphere, land)
- Modeling and simulation of microwave systems [link budget, remote sensing, microwave, experiments...]

## FOCUS

### DETECTION AND TRACKING OF MARINE TARGETS USING RADAR DATA

These algorithms use thresholdless measurements in scenario where conventional approaches have failed, due to weak signal to noise (SNR) ratios or environmental constraints. An original algorithm was developed in partnership with Diades Marine, in the context of the ADEME e-PANEMA project [e-Positioning et Aide à la Navigation en Environnement Maritime] and was awarded the IEEE Antennas and Propagation Society Award, 2019. It was developed using particle filters for the detection and tracking of targets; its performance was evaluated with the help of real radar data.

## RESEARCH PROGRAMS

- e-PANEMA : e-positioning and navigation support in the maritime environment (financed by Ademe ; with SAFRAN, Diades Marine, ENSM).
- CEPAMOCS : Characterization and retrieval of heterogeneous sea surface parameters observed by different satellite sensors (financed by DGA, AID, EGS).
- SLERECIM : The addition of GBS and GBL to the estimation of complex target reflectivity at sea (financed by DGA, AID, OAR).
- RCS measurements of targets in free space (financed by Naval Group)
- DOREDO : Detection of obstacles by radar embedded on drones (financed by DGA ; with CESTIM, CNAM Paris).
- TAPERE : Scalable deep learning techniques for target detection and reconnaissance using heterogeneous data (financed by DGA, AID, I2R).

## 3 THESES DEFENDED IN 2019

- **Nāïma AMROUCHE** (financed by an allowance from the Algerian Government ; with the National Polytechnic School of Alger) : « Detection, localization and tracking of maneuvering targets – Methods and algorithms for target tracking ».
- **Honglei ZHENG** (Chinese grant ; with the Ocean University of Qingdao, China) : « Study of the electromagnetic signature of a sea surface with and without an oil slick ».
- **Clément ROUSSEL** (DGA grant) : « Stochastic differential equations for the electromagnetic field issuing from the sea surface; remote sensing applications ».

# CUTTING EDGE EQUIPMENT IN THE RESEARCH INSTITUTE

FOCUS

## A 1,600 m<sup>2</sup> extension in mechanical sciences

The research institute in mechanical sciences has been extended. A new 1,600 m<sup>2</sup> building, over two floors, was inaugurated in March 2019, bringing the total surface area for the IRDL Laboratory to 4,000 m<sup>2</sup>. The new testing facilities have also been progressively deployed. A space is dedicated to the study of pyrotechnic phenomena and many other specialized rooms boast sophisticated equipment for studying mechanical properties, such as a triboindenter for observations and measurements on a nanometric scale. This new building also encourages the growth of research teams and the integration of research professors and teachers, doctoral students, post-docs and interns to the Dupuy de Lôme Research Institute (IRDL).

## A 850 m<sup>2</sup> renovation dedicated to cybersecurity

After a total renovation of the information technologies wing of the research institute (the Lab-STICC Laboratory), a research facility dedicated to cybersecurity programs was inaugurated in October 2019. It is comprised of several offices, secure rooms and much equipment acquired within the framework of the "Cyber SSI" strategic project.

## Acquisitions on-going within the CPER 2015-2020 framework

The exceptional test facilities in ENSTA Bretagne's research institute have been completed thanks to the strategic programs defined by the Contrat de Plan État-Région (CPER) Regional Development Plan. For the 2015-2020 period, 5 subjects were led by ENSTA Bretagne.

- Cyber SSI (cybersecurity of software and physical systems)
- SMD-MAR (marine environment observation using autonomous underwater robots).
- SOPHIE (maritime environment characterization by a microwave system).
- I-ROMI (design of new, passive acoustic observatories, following submarine ambient noise relating to geological phenomena, fauna and human activities).
- ECO-SYS-MER (to ensure the reliability of mechanical systems interacting with the marine environment, from the scale of the material to that of the system).

**5 strategic research  
programs representing  
new equipment worth  
5,6 M€ from 2015 to 2020  
(financed by the CPER<sup>1</sup>),  
be it 635 k€ of investments  
for the year 2019.**



### The MASMECA technology platform

It occupies 1,200 m<sup>2</sup> of ENSTA Bretagne's research institute. Its numerous experimental facilities aim to characterize the mechanical properties of all types of materials, assemblies and structures, on several scales, studied by the IRDL Laboratory.

5 experimental centers:

- Dynamic characterization (high speed load tests)
- Thermo-mechanical characterization (controlled environment and mechanical condition loading)
- Physico-chemical characterization (evaluating the effect of microstructure on the mechanical behavior of materials)
- Measurements and observations
- Prototyping

More info : [masmeca.ensta-bretagne.fr](http://masmeca.ensta-bretagne.fr)

<http://bit.ly/MASMECAfr>



### ENSTA Bretagne's information technologies resource center also boasts extensive experimental facilities :

- Anechoic chamber
- Soft Defined Radio Platform
- Drone systems and robotics area
- Test tank
- Hydrographic vehicles
- Cyber area ...

<sup>1</sup> CPER : Contrat de Plan État-Région (the state regional development plan)

Professional training  
and apprenticeships  
training  
EA 7529

# FoAP

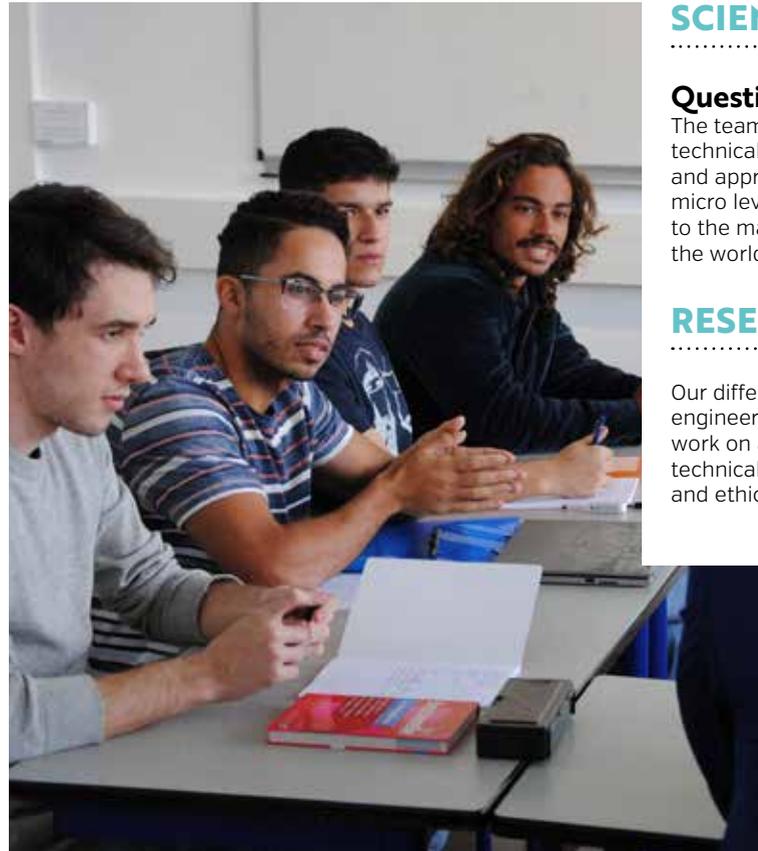
## RESEARCH UNIT

**99**  
MEMBERS, INCLUDING  
44 DOCTORAL  
STUDENTS, AND  
27 RESIDENT  
FELLOWS,

— ○ —  
INCLUDING 22  
RESEARCHERS AND  
13 DOCTORAL STUDENTS  
IN THE ENGINEER  
TRAINING AND  
PROFESSIONALIZATION  
TEAM (FPI)

### PROFILE

- Created on 1 January 2019, FoAP replaced the CRF [Centre de Recherche sur la Formation - Training Research Center]
- It unites the human science teams of ENSTA Bretagne, Cnam Paris and AgroSup Dijon.
- Under « Hosting Team » status : EA 7529
- It is under collegial governance. Denis Lemaître, professor at ENSTA Bretagne was named as its director.
-  [bit.ly/webFoAP](https://bit.ly/webFoAP)



### SCIENTIFIC PROJECT

#### Question the career and training of engineers.

The team studies the relationship between the social and the technical, from a point of view of identities, knowledge, organization and apprenticeship. They integrate socio-cultural dynamics from the micro level [for example, the individual facing the technical system] to the macro level [for example, engineer training systems around the world].

### RESEARCH PROGRAMS

Our different projects focus on the innovation training of responsible engineers in terms of sustainable development in every sense. We work on a sociotechnical approach to problems, which encompass technical, economic, legal, human, social, environmental, political, and ethical components...

### CONTACTS

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## FOCUS

### ENGINEER TRAINING AND PROFESSIONALIZATION (FPI TEAM) LAUNCH OF A NEW PROFESSIONAL TRAINING AND APPRENTICESHIP TRAINING LABORATORY (FOAP)

The Cnam Paris, ENSTA Bretagne and AgroSup Dijon have united their human science teams by creating a reference laboratory on Education and Training Science, on a national and international scale, on questions of training in the broad sense : initial professional training, higher education, life-long learning, active apprenticeships, career paths. Engineer training forms a major part, especially the idea of responsible innovation training and sustainable development, an area of particular attention for the FPI team at ENSTA Bretagne.

Historically, initial and continuous professional training have been a focus of activity for the Ministry for Armed Forces, and the Ministry for Food and Farming. The two schools, ENSTA Bretagne and AgroSup Dijon, steeped in this culture, have found another establishment for which this is also the main aim – the Cnam. The teams from Dijon, Paris and Brest have thus known each other and worked together for a long time.

Three key themes :

- Designing training, learner knowledge and skill transmission
- Curriculum and identity dynamics
- Activity and professional apprenticeship areas

# ENGINEER TRAINING AND PROFESSIONALIZATION (FPI TEAM)

## RIIME PHC Maghreb Project

« Recherche sur les Ingénieurs et la formation à l'Innovation au Maghreb face aux enjeux Environnementaux » (RIIME) [Research on Engineers and Innovation Training in the Maghreb facing Environmental Issues] is a project which is financed by the French Foreign Ministry, via CAMPUS France, the Algerian Ministry for Higher Education and Research, the Moroccan Ministry for Research and Higher Education and the Tunisian Ministry for Research and Higher Education. This project, which comprises 7 theses, studies the Maghreb, however, the questions raised may also be pertinent to France and Europe. The objective is to improve the contribution of scientific and technical training, to the training of responsible innovators, aware of major contemporary issues, in a context of complex relations between the needs in the field (companies/states/society), the developments in engineer training, and the extremely strong influence of international reference bodies which want to extend their influence and compete (CTI, ABET, CIDO etc).

## Questions on Pedagogy in Higher Education Colloquium, 17 – 21 June 2019 : « (Encouraging) cooperation to (encourage) learning »

This international and French-speaking colloquium was created in Brest in 2001, by IMT Atlantique (Brest site) and ENSTA Bretagne. It rapidly took off and traveled to different towns (Lille, Louvain-la-Neuve, Angers, Sherbrooke, Grenoble) gathering increasing numbers of participants.

For its tenth edition, the colloquium came back home, organized this time by ENSTA Bretagne, IMT Atlantique and the University of Western Brittany (UBO). It brought together 400 teachers and researchers. The diverse activities on offer were a great success : pre-colloquium teacher training, talks, communication presentation sessions, and teaching method workshops.

## The A-STEP2030 project

The ERASMUS+ project « Attracting diverse Talent to the Engineering Professions of 2030 » unites higher education institutions promoting innovation for training responsible engineers, able to respond to the societal challenges raised by sustainable development. More than 50 researchers and teachers from 6 European countries came together. The project consortium comprises seven members: ENSTA Bretagne (France), Dublin Institute of Technology (Ireland), Aalborg University (Denmark), Helsinki Metropolia University (Finland), Universum (Sweden), SEFI (European Society for Engineering Education) and BEST (Board of European Students of Technology) from Belgium. The project is coordinated by ENSTA Bretagne, headed by Klara Kövesi.

A-STEP 2030 started in September 2018 for 3 years. It aims to develop an innovative learning approach in agreement with the values and motivation of the learners. The objective is to train them in the necessary skills relating to sustainable development challenges and to attract young people to engineer training who will have this objective. Two European studies have been completed : one qualitative (in 4 European countries) on engineering skills to tackle sustainable development issues,

and a quantitative study (in 6 European countries) questioning the impact of young people's, students' and adult learners' values and motivation on their future choice of career.

The results were shared in three European workshops, four summer symposiums, one national conference, four papers, a webcast and five webinar.

More info: [www.astep2030.eu/en](http://www.astep2030.eu/en)

## « L codent L créent » project

This project is both a training and research initiative. The percentage of female engineering students is growing (27% of girls on average in 2016 /2017 compared with 19.9% in 1990/1991), but this development is not equally spread over all areas. Research supports the idea that the image and perception of the digital sector is the main explanation for this gap. Programming workshops for the high school girls of 6 establishments in the Brest area (3 in socially deprived areas), led exclusively by female undergraduates and from graduate engineering schools, were set up to try to change this image. From a sociological perspective of actors-actresses, this project aims to investigate the way in which the people involved in this initiative give meaning to their commitment and their actions.

More info: [ensta-bretagne.fr/fr/l-codent-l-creent](http://ensta-bretagne.fr/fr/l-codent-l-creent)

# CAMPUS

Ever evolving, ENSTA Bretagne's campus is expanding (cf. page 47), the **multimedia library** has had a make-over (to encourage collaborative work), the **video-conference** facilities have been increased (5 more rooms), a new ultra efficient **WIFI** service has been deployed throughout the students halls of residence (80 hubs, 1 Gb/s unfiltered connection).

## BUDGET : 24,8 M€

[CASH CREDITS 2019]

RESSOURCES	EXPENSES
Subsidy from the Ministry for Armed Forces ▼ <b>14,6 M€</b>	Staff ▼ <b>15,1 M€</b>
Other resources (research, training ...) ▼ <b>6,8 M€</b>	Operating costs ▼ <b>6,1 M€</b>
Equity ▼ <b>3,4 M€</b>	Investments ▼ <b>3,5 M€</b>

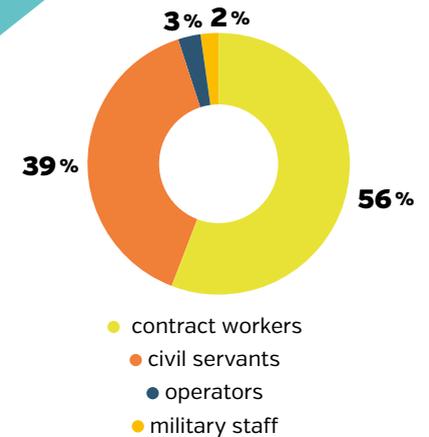
## NUMBERS

[NOT COUNTING DOCTORAL STUDENTS]

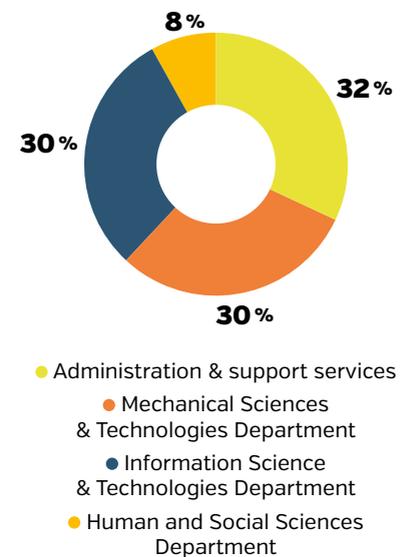
A multi-disciplinary team of **232** people

- > **74** lecturers [25 of which accredited doctoral supervisors]
- > **26** teachers
- > **19** technicians
- > **16** research engineers
- > **20** post-doctoral researchers
- > **77** support and supervisory staff [including 2 apprentices]

## STAFF STATUTS



## STAFF MISSIONS



1/3

OF THE APPLICATION PROJECTS AIM TO REDUCE THE ENVIRONMENTAL FOOTPRINT

30 %

FEMALE STUDENTS IN 1<sup>ST</sup> YEAR INTAKE FOR 2019, A SHARP INCREASE BY 10 POINTS

ENSTA Bretagne takes part in different discussions with the heads of sustainable development and social responsibility of the *Conférence des Grandes Écoles*. The school took part in the national sustainable development and social responsibility meeting, organized on 21 and 22 May 2019 in Strasbourg and the colloquium « Societal changes and new skills. What are the impacts on organizations? » on 2 October 2019 in Paris.

# SUSTAINABLE DEVELOPMENT & SOCIAL RESPONSIBILITY



## ACTING FOR SUSTAINABLE DEVELOPMENT

ENSTA Bretagne trains future innovators, responsible engineers prepared to act for sustainable development. This major challenge is taught and applied within the framework of practical projects. It is also at the heart of many mechanical science, information technology and human science research programs.

- The design of less energy consuming **transport** systems.
- The reduction of the environmental impact of **cities** and the encouragement of « intelligent » services.
- The detection of **pollution** on ocean surfaces.
- The development of marine **renewable** energies
- The measurement of the **impact** of climate change.
- The monitoring and tracking of marine **mammal** populations
- The **heightening** of student awareness of the need for sustainable development in all their engineering projects.

## SOCIAL RESPONSIBILITY TRACK RECORD

ENSTA Bretagne defends the values of openness, tolerance, diversity and is pro-active in reducing inequalities and ensuring the well-being of everyone at work.

- Preventing and combating harassment and all forms of discrimination (« **stopdiscr** » network).
- Encouraging and endorsing citizenship and solidarity **commitments** on the part of the students.
- Changing attitudes to disability and informing future engineers of how to receive people with **disabilities** in the professional environment
- Stimulating the interest of young girls in science and engineering to improve the **gender balance** in these careers.



The ENSTA Bretagne Enactus club promotes social entrepreneurship and solidarity.



# ENSTA BRETAGNE

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