# ACTIVITY REPORT



A LEADING INNOVATOR THROUGH COLLABORATIVE RESEARCH



Robert Brunck President



Patricia Renaud, Director

### **EDITORIAL**

ARMINES's mission is to conduct research and training through research in collaboration with its partner schools. The 48 research centres we share with them interact across all business sectors. The 600 ARMINES employees who work there every day alongside the school staff contribute to implementing research projects geared to the needs of the socio-economic world. Combining scientific excellence and the co-creation of new knowledge, products, or services with companies is part of our DNA and that of our schools.

ARMINES, partner and operator of Écoles des Mines working towards partnership research, has become the benchmark in terms of contract management (about 1,000 new contracts/ year), with national or international companies, public research operators (such as CEA, CNRS, and INRIA), academic operators (universities, schools) and public funders (such as Europe, ANR, ADEME, and BPI France), and finally, in terms of skills transfer. Each year nearly 130 PhD students employed by ARMINES are trained by the schools in our centres.

# Our business model introduces real financial leverage (consolidation of public/private resources), in order to fund scientific resourcing which cannot be financed by the government alone.

TRANSVALOR SA, of which ARMINES is the reference shareholder, also plays a role in initiating new activities resulting from the centres' research work and in the increasingly important initiation of spin-offs from the schools.

Today, the landscape of French higher education and research is changing rapidly with consolidation at the regional level around HE&R Clusters. Our partner schools are also involved in this, notably MINES ParisTech, a member of Paris Sciences et Lettres - PSL Research University. For their part, the regionally-based Écoles des Mines were integrated into IMT in early 2017.

ARMINES's historical operational know-how, business model and managerial culture adapt to this evolution. Our actions and commitment will remain at the service of the country's economic development, and we will continue to train engineers in the new skills necessary to confront the industry of the future and other issues, such as health or sustainable development, while integrating the digital transformation.

We would like to thank the ARMINES and the school staff for their dynamism, and the companies for their belief in us. We will all have the pleasure of meeting in 2017 to celebrate our 50th anniversary with the schools and our partners, and to plan for our future together.

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# ARMINES, **A UNIQUE** ORGANISATION **IN FRANCE**

Research work carried out by ARMINES within the framework of the Schools-ARMINES joint research centres is eligible for research tax credits, under the same terms as public laboratories (article 244.4 quater **B** II of the French General Tax Code).

### A PRIVATE STRUCTURE DEDICATED TO PARTNERSHIP RESEARCH. TRAINING THROUGH RESEARCH AND **DEVELOPING RESEARCH RESULTS**

ARMINES operates within the framework of the law of 18 April 2006 which allow public higher education or research institutions to entrust their contractual research activities to private-sector organisations. ARMINES is bound by agreements approved by the French government to its partner schools, including first and foremost MINES ParisTech and the other Écoles des Mines, under the supervision of the French Ministry of Economy and Finance: MINES Albi-Carmaux, MINES Alès, MINES Saint-Étienne, IMT Atlantique Bretagne-Pays de la Loire and IMT Lille Douai. ARMINES operates in the Polytechnique, ENSTA ParisTech, École Navale and the École des Ponts ParisTech laboratories.

### REACTIVITY, PROXIMITY AND EFFICIENCY

With its status as a non-profit making association under the terms of the 1901 law, ARMINES has the managerial autonomy required to act swiftly, therefore empowering the research centres to deal with the economic world in an effective manner: the ability to decide, make commitments and react quickly, unfettered by bureaucratic red tape, and therefore be capable of undertaking activities for which researchers must have a free hand. Staffed by 571 employees, ARMINES contributes to the development of research centres it shares with its partner schools.

















The regionally-based Écoles des MINES were integrated into IMT on 01/01/2017. Two of them have also merged: MINES Nantes with Télécom Bretagne and MINES Douai with Télécom Lille to become IMT Atlantique-Bretagne-Pays de la Loire and IMT Lille Douai, respectively



VIDEO REPORT ON INNOVATION IN FLEXIBLE PRINTED ELECTRONICS: http://bit.ly/2qVLpL





ST PARTNERSHIP-**BASED RESEARCH ORGANISATION IN FRANCE** 







# ARMINES COLLABORATIVE ACADEMIC RESEARCH

From research to technological transfer, nearly 600 private-sector individuals working toward a shared mission with the Écoles des Mines.

### **ARMINES STAFF** WITHIN SHARED RESEARCH CENTRES

### CONTRACT MANAGEMENT OF **THE INDUSTRY-RESEARCH RELATIONSHIP**

### PERMANENT **STAFF IN CHARGE OF MANAGEMENT**

- Putting together and managing partnership research, direct manufacturer, public collaborative or European contracts.
- Support for research teams.
- An intellectual property strategy and valuing of research results.
- Support roles (HRM, accounting, finance, legal, communications, web marketing)
- Management of the Institut Carnot M.I.N.E.S.

### PERMANENT STAFF **IN RESEARCH CENTRES**

### **LECTURER-RESEARCHERS. RESEARCH ENGINEERS. TECHNICIANS AND** ADMINISTRATIVE STAFF

- Permanent resources shared with the schools in the research centres.
- Long-term, high-level skills.
- Cutting-edge technological, metrological and software platforms at the heart of the research centres.

### **A VECTOR FOR TRANSFERRING** INNOVATION **THROUGH SKILLS**

### DOCTORANTS, **POST-DOCS AND TEMPORARY CONTRACT EMPLOYEES**

- Training through research, in contact with industrial and economic issues.
- Learning two cultures.
- A springboard for PhD students and post-doctoral fellows.
- A breeding ground for innovation in companies.

### **TRANSVALOR:** A SUBSIDIARY FOR CREATING AND VALUING RESEARCH-**BASED BUSINESS**

### **STAFF MEMBERS** RESPONSIBLE FOR HIGHLIGHTING VALUE

- Support for projects linked to technological maturation and industrial and commercial development.
- Industrialisation, support and marketing for the technical and scientific software developed within the research centres.
- Involvement in and support for technological spin-offs.
- Presse des Mines (scientific publishing house).

ARMINES offers contractual PhD students the opportunity to confront issues of economic interest. As such, it plays the role of a 'jobs springboard' for more than 100 PhD students each year hired on private contracts.





ONLINE VIDEO: http://bit.ly/2soX7zF





STEERING HUB (CDP BHARAT FORGE GMBH) STAMPING WITH FORGE® NXT

# ACADEMIC BUSINESS RESEARCH CENTRES

The ARMINES-Schools public-private partnership is very flexible and ensures a high level of reactivity. Depending on the nature of the research and the expectations of its partners, ARMINES and the schools form aptly-chosen, customised project teams and complete the State's resources in terms of investment, functioning, logistics and human resources.



### JOINT ARMINES-SCHOOLS CENTRES

Each centre has its own skill, a scientific department with, in terms of management, the objective of annually balancing its operating account while ensuring its actions are part of its school's strategic objectives.

# AN ENTREPRENEURIAL APPROACH

ARMINES has a very flat structure which functions according to the principle of initiative and accountability under demanding economic constraints. The scientific teams themselves are in an entrepreneurial situation with fixed costs not covered by the State's budget.

Taking all expenditure (including payroll) together, some ARMINES/MINES ParisTech joint research centres operate on practically 50% budget funds and 50% contractual resources. This constitutes something of an oddity within the French higher education and research landscape.

Our heads of centre combine scientific excellence in internationally recognised teams with consideration of the socio-economic needs.

### RESEARCH STRUCTURED AROUND TECHNOLOGICAL AND SOFTWARE PLATFORMS

The research partnership is based in part on the implementation and development of scientific results in experimental, metrological, IT or software platforms, the idea being to turn a scientific breakthrough into a result which can be exploited by the industrial world.

The close link between high-level scientific skills and these technological platforms that put ideas into practice under the supervision of qualified permanent staff, makes it possible to go from the idea to the proof of concept on a trial version. The companies thus remove some of the risk prior to setting their product development in motion.

# AN INTERNATIONAL DIMENSION

Half of the partnership research activity is directly conducted with the companies, 15% of which are foreign companies

# A BALANCED AND PRAGMATIC CONTRACTUAL MODEL

Contract research is at the heart of ARMINES' skills.

Its partner businesses provide financial support which covers a share of the full cost of projects.

The contracts are not services, but part of a publicprivate technical-economic partnership.

This set of circumstances creates reciprocal rights and obligations for the company and research centre:

- the right to use the results in stakeholders' acknowledged areas of expertise;
- the right to publish and support theses;
- the legal sharing of intellectual property, for the purpose of developing a coherent intellectual heritage and the capacity for each partner to progress in their own field.

Balancing training, academic activities and contractual research is at the heart of ARMINES' management dynamics.

# 5 FIELDS OF SRESEARCH

- MATERIALS SCIENCE AND ENGINEERING
- ENERGY AND PROCESS ENGINEERING
- EARTH AND ENVIRONMENTAL SCIENCES
- MATHEMATICS AND SYSTEMS
- ECONOMY, MANAGEMENT AND SOCIETY

# 8 MAIN THEMES ON THE FUTURE

- FUTURE INDUSTRY/INDUSTRY 4.0
- 🚔 MOBILITY AND SUSTAINABLE TRANSPORT SYSTEMS
- 😔 FUTURE HEALTH/E-HEALTH
  - SOCIETY AND SECURITY
  - INNOVATIVE, INTEGRATIVE, AND ADAPTIVE SOCIETY
  - DIGITAL TRANSFORMATION
  - ENERGY TRANSITION
  - ENVIRONMENTAL TRANSITION

# **A VARIETY OF PARTNERSHIP MODES**

- FRAMEWORK AGREEMENTS
- DIRECT CONTRACTS FOR RESEARCH
- INDUSTRIAL CHAIRS
- SHARED LABORATORIES
- INDUSTRIAL CONSORTIA
- COLLABORATIVE RESEARCH PROJECTS

- TECHNICAL SERVICES
- OPERATING LICENCES
- SPIN-OFF: INITIATING SPIN-OFFS
- CONTINUED LEARNING
- INDUSTRIAL THEME DAYS



# **OVERVIEW OF A YEAR** OF RESEARCH FOCUSED ON SOCIO-ECONOMIC NEEDS



Self-driving cars hit the road (Euronews report)

### ⇒ http://bit.lv/2uHl6df

### $\heartsuit$ FUTURE INDUSTRY/INDUSTRY 4.0

### ADVANCED DIGITAL MODELLING FOR COMPOSITE MATERIALS MINES SAINT-ÉTIENNE / HEXCEL AIRBUS SAFRAN / INDUSTRIAL RESEARCH AND TEACHING CHAIR

After selecting the Roussillon site to establish its carbon fibre production plant, Hexcel, the world leader in advanced composite materials, chose MINES Saint-Étienne for its first-ever industrial chair. The research project carried out by Professor Sylvain Drapier will focus on understanding, modelling, simulating, and mastering the liquid resin infusion fabrication of high-performance composite materials for aeronautics. This innovative manufacturing process consists of creating a flow of resin by evacuation through a fibrous structure previously produced by additive deposition of dry reinforcements. It is through the pooling of physicallybased mathematical models developed by MINES Saint-Étienne in a high-performance computing environment, and the follow-up and implementation methods devised by Hexcel's technical teams, that a technological breakthrough in materials and processes was created in response to the challenges faced by major aeronautics customers such as **Airbus** and **Safran**, the sponsors of this chair. This chair will have a direct impact on the Mechanics and Materials major of the school's Civil Engineering degree. The joint contribution of Hexcel, MINES Saint-Étienne and ARMINES represents a budget of  $\in$  3 million over five years.



### A SUCCESSFUL COLLABORATION ON THE INTELLIGENT CITY

### IMT ATLANTIOUE<sup>\*</sup> / H2020 EUROPEAN PROJECT

The Energy Systems and Environment centre at MINES Nantes - ARMINES and Logic of Uses, Social Sciences, and Information departments at Télécom Bretagne have combined their efforts and know-how within the MySmartLife\*\* project. This five-years European H2020 project is part of the "Smart Cities & Communities" program designed to develop technological solutions that will support the smart cities of tomorrow, in addition to the Smart City strategy deployed by Nantes Métropole. The two partners will mobilise their expertise to model the Centre Loire urban heat network and to set up a decision support platform to assist with choosing more efficiently between various innovative energy management solutions. Following the LoraCroft project dedicated to the study of the compatibility of wireless transmission solutions for monitoring heat networks, developed jointly by MINES Nantes and Télécom Bretagne, MySmartLife illustrates the relevance of the dual-institution partnership for digital technology and energy.

° IMT Atlantique Bretagne Pays de la Loire is the result of the merger of MINES Nantes and the Institut MINES Télécom Bretagne effective as of 1st January 2017. \*\* The MySmartLife project is funded under the European Union's Horizon 2020 program under accreditation number 731297

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 731297.



SELF-DRIVING VEHICLES AND COOPERATIVE DRIVING MINES PARISTECH / DRIVE FOR ALL/INTERNATIONAL RESEARCH CHAIR IN AUTOMATED DRIVING, IN PARTNERSHIP WITH VALEO, GROUPE PSA AND SAFRAN

With a view to making traffic flows faster and safer for autonomous cars, the MINES ParisTech - ARMINES robotics centre are developing numerous research projects on **cooperative driving** with stakeholders in the automotive industry.





## OVERVIEW OF A YEAR OF RESEARCH FOCUSED ON SOCIO-ECONOMIC NEEDS

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### A TECHNOLOGICAL PLATFORM FOR CONVERTING WASTE INTO ENERGY

### MINES ALBI / TECHNICAL SERVICES/RESEARCH

After **Mimausa** and **Gala**, MINES Albi inaugurated Valthera\*, its third innovation and research platform, specialising in **developing thermal processes for energy recovery from biomass**. Thanks to a comprehensive technological offer, including drying, pyrolysis, roasting, combustion and gasification, it allows regional SMEs to access state-of-the-art equipment and the internationally recognised expertise of the **Rapsodee** laboratory to fulfil their R&D program on deriving energy from agricultural, forestry, agri-food, and industrial products. Various avenues of energy production are explored in the form of new energies or materials with added value.

"VAlorisation THErmique des Résidus de transformation des Agro-ressources".

# ENERGY TRANSITION

# TWO NEW INDUSTRIAL CHAIRS ON DIGITAL METALLURGY AND URANIUM RECOVERY

### MINES PARISTECH / ANR INDUSTRIAL CHAIRS

The eligibility of ARMINES for the full coverage of the cost of industrial chairs registered by the MINES - ARMINES joint centres allowed to finance (50% by the ANR and 50% by industrial partners) two new chairs for a total amount of  $\epsilon_3$  M over four years. These two chairs are among five industrial chairs selected by the ANR in 2016 at the national level.

• The first, the DIGIMU chair, aims to meet the needs of the metallurgical industry in the high-tech materials sector. As a result of a partnership between MINES ParisTech, ARMINES and seven partners (ArcelorMittal, AREVA, ASCOMETAL, Aubert & Duval, CEA, Safran and Transvalor), its objective is to develop a multi-scaled digital framework to better understand the changes in the properties of materials during actions to shape metal parts. The tool developed, dubbed Digimu, will be distributed by Transvalor and will integrate the expertise and feedback of the industrial companies present in the chair.

PHD A. AGNOLI / DIGIMU

A MESH OF COMPLEX FINISHED ELEMENTS ADAPTED TO A STATISTICAL DESCRIPTION

OF PARTICLES AND AN EXACT REPRESENTATION OF SECOND-PHASE PARTICLES IN THE CASE OF L'INCONEL718.

• The second chair, ISR-U\*, focuses on uranium recovery technologies. It is part of the long-term partnership between **AREVA** and the MINES ParisTech-ARMINES Geoscience centre. It involves conducting upstream research to identify chemical reactions at work in the uranium leaching process and develop models to simulate them.

... DIGITAL TRANSFORMATION



### SOCIETY AND SECURITY

# A ROADMAP FOR EVALUATING COMPLEX SYSTEMS ARCHITECTURES

### LGI2P MINES ALÈS / THALES / DIRECT RESEARCH CONTRACT

Thales used the LGI2P laboratory at MINES Alès to take stock of its work on the evaluation of complex systems architectures and to establish a path for a research program for the years to come. The objective is to have an external vision and analysis of their work, their positioning and the possible progress to be made over the next five to ten years. The ISOE team from the LGI2P laboratory received three awards from the French Association of System Engineering for its work in the design of complex systems. In particular, it has been involved in developing an evaluation approach for the architectures of such systems. These special skills combined with impressive know-how in modelling, verification and validation allowed it to carry out this work.





### **FUTURE HEARTH/E-HEALTH**

### A VIRTUAL ASSISTANT FOR ALZHEIMER PATIENTS CRI MINES PARISTECH/BROCA HOSPITAL/CENTRE OF NATIONAL EXPERTISE IN COGNITIVE STIMULATION/COLLABORATIVE RESEARCH PROJECT

With an ageing population, the number of elderly people with neurodegenerative diseases - including Alzheimer's disease - is increasing. There is also a lack of caregivers to care for those with the loss of independence. For the last three years, the Centre for Computer Science Research (CRI) at MINES ParisTech - ARMINES has been working with **Broca Hospital and the Centre of National Expertise in Cognitive Stimulation** to propose innovative solutions inspired by the world of video games. Consequently, Pierre Wargnier's thesis, co-directed by MINES ParisTech and the Paris Descartes University, focused on designing a virtual character named LOUISE (for LOvely User Interface for Serving Elders). Able to communicate through gesture and speech, it serves as an interface in support mechanisms for elderly people with cognitive impairments. This research has resulted in several publications and will continue with a post-doctoral contract funded by ARMINES to explore the possibilities for industrial use of this work and with a new doctoral contract that will ensure the continuity of this fruitful partnership for the next three years.

KOCLIKO, ENERGY TRANSITION ACCELERATOR

CES MINES PARISTECH / SPIN-OFF

The Eco-Design Chair for Buildings and Infrastructures at the Centre for Energy Efficient Systems (CES) MINES ParisTech - ARMINES aims to better integrate environmental aspects into building design. Significant development work carried out by the software publisher **Izuba Energies** allowed to integrate the models resulting from this work into widely distributed operational tools, compatible with the new interoperability standards and approved by most certification schemes. Founded in May 2016 by two young PhD students from the CES and a third developer, the Kocliko spin-off intends to complete this software platform with multi-criteria optimisation tools (energy balance, construction costs, environmental impacts) and uncertainty calculations. **This set of tools will support industry professionals in meeting the new energy transition goals.** 





### **EUTURE HEALTH/E-HEALTH** THIRD ERC GRANT FOR RÓISÍN OWENS

### CMP MINES SAINT-ETIENNE/EUROPEAN RESEARCH COUNCIL/ERC CONSOLIDATOR GRANT

A researcher at the Microelectronics Centre of Provence - Georges Charpak Campus at Saint Etienne MINES - ARMINES, Róisín Owens has just been awarded an European Research Council (ERC) grant for the third consecutive time. After the "Starting Grant" and then the "Proof of Concept", this time she has won the "Consolidator", in other words she has a 100% success rate in her requests for funding from the ERC. This valuable and prestigious aid will allow her to pursue her research in bio-electronics. Entitled **IMBIBE**, the project for which she has just obtained €2 million over five years consists of **developing an** *in vitro* model to study the presence of microbiota and its effect on the intestines and pathophysiology of the brain. The advantages of this method are twofold: fewer animal tests and better pre-clinical results (real-time monitoring and the possibility of iterative improvements) in response to the enemies of our society such as obesity, anxiety, colorectal cancer and autistic disorders.

### EUTUREINDUSTRY/INDUSTRY4.0 3D-PRINTED PLASTURGY

IMT LILLE DOUAI/TOTAL/RESEARCH CONTRACT

For several years now, additive manufacturing by 3D printing has been at the heart of the work carried out in the TPCIM centre at IMT Lille Douai - ARMINES. The first international laboratory to be equipped with **Arburg**'s Freeformer technology, the centre is studying, optimising, and modelling the process, developing specific materials, and analysing the structural and physical properties of parts made directly from thermoplastic granules. Several industrial partnerships have been set up, including one with the **Total** group. The objective is to **develop industrial solutions for producing additive polymers on materials of interest to Total**, and thus by extension for the entire industrial sector of the plastics industry.



OVERVIEW OF A YEAR OF EXCHANGES WITH VALUE PROPOSITION COMPANIES





SOCIETYAND SECURITY EUTURE HEALTH CONNECTED WEARABLES FOR MORE SECURITY AND MEDICAL PATIENTS

MINES SAINT-ÉTIENNE / MINES PARISTECH / RESEARCH CONSORTIUM

Launched in November 2016, the AUTONOTEX project focuses on developing connected wearables for people in high-risk professions or medical patients. Financed by the Banque publique d'investissement (Bpifrance) in the framework of industrial projects for the future. it is supported by 6 industrial partners and 7 academic partners, including the Materials Centre (connected to MINES ParisTech - ARMINES) and the Micro-Electronics Centre of Provence (shared by MINES Saint-Étienne-ARMINES). This consortium brings together the complete value chain: research, development and prototyping, industrialisation. production and marketing of these **new** intelligent, connected and autonomous textile products.

For more INFORMATIONS: http://bit.ly/1YvQ6VK

### **5 NEW FRAMEWORK AGREEMENTS**

\* French national research agency

The detailed contract created by ARMINES offers a flexible framework for carrying out collaborative research actions. Five agreements were concluded in 2016:

- between **IMT, ARMINES and ELM Leblanc**, for research on stainless steel, acoustics, energy, big data, machine learning and the industry of the future;
- between the Materials Centre and Cemef MINES ParisTech ARMINES, ESPCI and
- Hutchinson (Total Group) for the "Deep" industrial chair for optimising the sizing of industrial parts;
   between CERN and the Materials Centre at MINES ParisTech ARMINES,
- for scientific collaborations in the field of materials mechanics;

• between **Géosciences MINES ParisTech, MINES Alès, MINES Nancy, ARMINES, and ENSG** to build a network of excellence in mining and quarrying;

• between Storengy (Engie) and Géosciences MINES ParisTech - ARMINES

to renew the framework agreement with a license for the R&D of the Cysis, Diplef 3D and Demether software packages developed from the Géosciences research.

### **5 EXAMPLES OF INTELLECTUAL HERITAGE USES**

### 3 licences

• to Arysta Science Innovation for innovation in bacterial viruses with LGEI MINES Alès - ARMINES;

• to **Liphatec** for using a process for manufacturing a rodenticidal active molecule developed by the Rapsodee Centre at MINES Albi - ARMINES;

• to Geostock for using software packages created by Geosciences MINES ParisTech - ARMINES.

### 2 transfers

• to **Solaronics**, the license of Pac Facteur 7 technology for producing hot water from wastewater heat, resulting from the work of the Centre for Energy Efficient Systems (CES) MINES ParisTech - ARMINES;

• to **RTE**, the Optimate software for technical and regulatory analysis of electricity markets created by CMA MINES ParisTech - ARMINES.

### INDUSTRIAL MEETINGS IN WHICH RESEARCHERS PRESENT THEIR VALUE PROPOSITIONS TO COMPANIES

In 2016, five industrial meetings were organised under the aegis of the Institut Carnot M.I.N.E.S It was an occasion to promote the skills and know-how of researchers in its research centres to more than 200 companies. The Institute also attended the main professional sector events (in materials, aeronautics, etc.) as a supplier of scientific and technical solutions for companies looking to innovate.



### A TEAM DEDICATED TO ENERGIES OF THE FUTURE

For the last four years, the Carnot M.I.N.E.S and Energies du Futur institutes have been involved in the AVENEPME\* program, so as to provide innovative industrial solutions and **increase the competitiveness of VSEs, SMEs and ETIs in the field of future energy.** Resources allocated to the program have helped: • organise and conduct meetings with companies across the country, to gather their R&D and innovation needs and present them with solutions; • technology to mature by creating proof-of-concept models (TRL 4-5) to **encourage socio-economic actors to take up research results**.

\* Future Investments scheme funded by the French National Research Agency (ANR)



# 600 COMPANIES MET

**50** MEETINGS BETWEEN BUSINESSES AND RESEARCHERS

570 NEEDS GATHERED

O CONTRACTING BUSINESSES, AND OVER €2 MILLION IN TURNOVER

PROOFS OF CONCEPT FUNDED BY THE PROGRAM



In situ solar radiation measurements accessible on the web (Proof of concept from the O.I.E. centre at MINES ParisTech - ARMINES) ⇒ http://bit.ly/2qa8XwL



How to optimise a data centre's energy consumption? (Proof of concept from the Automatic Computing Department at IMT Lille Douai - ARMINES) ⇔ http://bit.ly/2qfgpTh

### WATCH MORE AVENEPME ON YOUTUBE

- Digital platform for calculating the interesting properties of biogas (Proof of concept from the CTP centre at MINES ParisTech - ARMINES) ⇒ http://bit.ly/2rg3dBM
- Generation of hydrous grease ice by CO2 capture (Proof of concept from the SPIN Centre MINES Saint-Étienne - ARMINES) ⇒ http://bit.ly/2uxL4QC
- ► How to refrigerate without frost? (Proof of concept from CES MINES ParisTech - ARMINES)  $\Rightarrow$  http://bit.ly/2qVbmIF
- CRESUS: Predictive solar water heater (Proof of concept from
   the PERSEE centre MINES ParisTech ARMINES) ⇔ http://bit.ly/2rghv54
- PROCESS'ALG: Microalgae cultivation for manufacturing biomaterials (Proof of concept from the C2MA centre MINES Alès - ARMINES) ⇔ http://bit.ly/2giN6yo

# AN INSTITUT CARNOT-APPROVED ORGANISATION



The Institut Carnot M.I.N.E.S brings together the research forces of ARMINES, the six Écoles des Mines attached to the ministry responsible for industry, three laboratories of the École Polytechnique and ENSTA ParisTech, and four foundations. In July 2016, the Carnot label of the institute was renewed by the ministry responsible for research. Carnot M.I.N.E.S remains in the "circle" of the 17 institutes whose label has been renewed every time since its creation in 2006.

The year 2016 saw several key moments:

- In January, the Investissements d'Avenir (Investments for the Future) program launched eight "Carnot sector" projects to support VSEs, SMEs and ETIs in their innovation needs over the next six years. The Institut Carnot M.I.N.E.S is a partner of six sector projects and coordinates the fashion and luxury sector through the CARATS project (see box).
- In September, around a hundred companies came to discover 57 proofs of concept designed to encourage their take-up of research results at the Future Energy SME Meetings in Grenoble.
- Finally, in November, the Institut focused its in-house seminar on showcasing its intangible heritage. It brought together researchers accompanied by external experts and enabled us to draft the 2017 action plan.

For more informations: www.carnot-mines.eu



The Institut Carnot M.I.N.E.S in 2016 ⇒ http://bit.ly/2rSEAan

### A STRATEGY BASED ON PARTNER RESEARCH

The Carnot label is awarded to public research organisations which simultaneously lead upstream research activities and have a proactive policy in terms of partnership research which benefits the socio-economic world.

### For this, they must:

- anticipate companies' needs,
- form closer links with private research stakeholders.

### The implementation of this roadmap is made easier by the payment of a contribution which finances:

- scientific resourcing work
- initiatives to structure partners' research.

### CARATS: INNOVATION SERVING THE COMPETITIVENESS OF THE FASHION AND LUXURY SECTORS

The Institut Carnot M.I.N.E.S leads the CARATS project, supported by the Investissements d'Avenir program. Conducted with the Carnot MICA and I@L institutes, it supports SMEs and ETIs from the fashion and luxury sector with their innovation needs in order to help increase their competitiveness. Sustainable development, creation and engineering, brand image and



identity, luxury of the future, and innovation management are all challenges that the three Carnot institutes intend to take up to allow the "French brand" to keep its position as international leader. The project allocates resources to foster companies' access to scientific skills and technology platforms and to develop the expertise offered by research institutes in response to the sector's specific needs.

**Contact:** Jean-Clément Guisiano, Innovation Support & Development manager ARMINES – Institut Carnot M.I.N.E.S jean-clement.guisiano@mines-paristech.fr **The largest** academic Institut Carnot boasting more than 2,000 research staff including 800 PhD students in 40 laboratories across 5 cross-school departments.

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energy and CO2	•	-			
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petroleum		-			
mineral resources	-		-	-	•
earth	-				
water	-				
air		•			
SECURITY					
surveillance	•				
risk management					
TRANSPORT					
automotive		•			
aeronautics		•	•		
infrastructure					
HEALTH			·		
biomedical					
bio-informatics					
healthcare management					
MATERIALS	I				1
PROCESSING					
preparation					
characterisation					
forming					
nano-technologies					
industrial processes					
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software engineering					
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innovative design methods					
business organisation					
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# MATURATION, TECHNOLOGICAL TRANSFER AND START-UP

TRANSFORMING RESEARCH RESULTS INTO INNOVATION: TRANSVALOR'S MISSION

### TRANSFORMING RESEARCH SOFTWARE INTO INDUSTRIAL CODE

ARMINES is the reference shareholder in TRANSVALOR SA destined to lead the process of transforming research results into innovation. **"Maturation"** is the intermediate stage between the research and the market.

TRANSVALOR fulfils this mission either internally or externally with a stake in **spin-offs based on technologies developed within the research centres**, mainly in the field of technical software.

In 2016, TRANSVALOR (60 employees) had a turnover of **68 million**, mostly in the field of industrialisation and marketing scientific software for simulating material forming (simulation of different forging and casting processes in particular) from CEMEF (MINES ParisTech - ARMINES joint centre) in Sophia Antipolis.

This area of activity called **"Transvalor Material Forming"** led by Emmanuel Chenot since April 2016, which has a subsidiary in the USA (TRANSVALOR AMERICAS), **generates nearly 70% of its turnover through exports with a strong presence in Asia.** 

### DELIVERING MORE RELEVANT RESULTS FOR INDUSTRY

More generally, TRANSVALOR launches **new activities issued by research centres** *via* its **"Transvalor Innovation"** department, managed by Etienne Wey, responsible for bringing projects to maturity.

This internal TRANSVALOR activity functions as a virtuous circle, which has the effect of reinforcing the ability of companies to use the results and thus bolster the research itself and its socio-economic impact.

It is a development tool for Transvalor which helps ARMINES research to stand out and builds loyalty among the industrial partners who can then leverage of the research results. Within the context of the joint centres with MINES ParisTech,

the following stand out:

- industrialisation of the **SODA** web service portal and HELIOCLIM solar radiation database developed at the O.I.E centre;
- simulation of the transfer of fluid in porous environments that take geochemical exchanges into account (CHESS and HYTECH software developed at the Geosciences Centre);
- development of the Mathematical Morphology Centre's **MORPH-M** image analysis software.

Since 2014, TRANSVALOR has invested heavily in supercomputing to simulate the interaction between fluids and structures, using a highly innovative "fluid-structure" simulation model developed at CEMEF (Material forming centre) coupled with an original SaaS-mode calculation platform developed by TRANSVALOR (**Aéromines** project).

Transvalor Innovation now handles the distribution of the **Z-set** structural calculation code developed at the materials centre in Évry (MINES ParisTech - ARMINES).

For each of these software developments, TRANSVALOR contributes to the development of codes and their industrialisation and generates the user interfaces and technical support.

### SUPPORTING RESEARCH CENTRE SPIN-OFFS

TRANSVALOR uses a share of the equity that it has built up to **provide seed funding for the first round of funding in particular**.

- In 2016 it was a shareholder in the following companies:
- GÉOVARIANCES (geostatistics, MINES ParisTech);
- AI4R (medical imaging, MINES Nantes);
- EASYVIRT (data centre management of calculation resources, MINES Nantes);
- **TERRA 3D** (3D imagery and big data for transport applications, MINES ParisTech's Robotics centre).

In 2014, TRANSVALOR acquired a stake in the Norwegian company **CEETRON**, a specialist in man-machine interfaces and the 3D visualisation of calculation results.



Aéromines: digital wind tunnels in SaaS mode (online) ⇒ https://youtu.be/tG4EvOAgipl



# EXAMPLES OF SOFTWARE MARKETED BY TRANSVALOR



**FORGE** software, developed by the CEMEF (MINES ParisTech - ARMINES joint centre), is a cutting-edge simulation tool for the forging industry. It is the ideal software solution to simulate hot and cold forming processes. WWW.ATLAS-SOLAIRE.FR

Industrialisation of the **SODA** web service portal and **HELIOCLIM** solar radiation at the O.I.E centre (MINES ParisTech - ARMINES).

WEBBING OF A BRAIN IN DIFFERENT LAYERS WITH AÉROMINES

The **Aéromines** project developed by the CEMEF (Material forming centre) follows on from the major investment initiated in 2014 in supercomputing to simulate interactions between fluids and structures. The platform is operational in "cloud" mode and in real time.



Transvalor Innovation handles distribution of the **Z-set** structural calculation code developed at the Évry (MINES ParisTech/ARMINES) Materials Centre in collaboration with ONERA.



The REM3D software launched commercially in 2015 is polymer material injection process digital simulation software, which is particularly innovative in terms of injecting polymer foams.

TRANSVALOR is a shareholder in **PERTINENCE INVEST**, an investment company created in conjunction with private "sister companies" (INSAVALOR, INPG ENTREPRISE, CENTRALE INNOVATION, ADERA, AMVALOR, ADRINORD, VALOR PACA) to pool financial resources and skills to support start-ups promoting the technologies of engineering schools' and partner universities' laboratories. By the end of 2016, PERTINENCE INVEST had acquired an equity stake in around fifteen start-ups.

TRANSVALOR handles **Presses des MINES**' publishing with around <u>thirty new titles</u> published each year ("Transvalor Edition").

**For more informations:** www.pressesdesmines.com

# 2016 FIGURES

### TOTAL ACTIVITY PER PARTNER SCHOOL IN 2016



### COMPARATIVE ACTIVITY

€ **42,2** MILLION IN 2016

€44,7 MILLION IN 2015



### BREAKDOWN OF NEW CONTRACTS BY COMPANY SIZE



### **STAFF ON 31 DECEMBER 2016**



### **STAFF PER ORGANISATION (PARTNER SCHOOLS)**

	2016
General management	56
MINES ParisTech of which	231
Évry	48
Fontainebleau	54
Palaiseau	33
Paris	24
Sophia	72
MINES Albi	36
MINES Alès	47
IMT Lille Douai	48
IMT Atlantique	44
MINES Saint-Étienne	47
ENSTA ParisTech	7
École polytechnique	6
Ponts ParisTech	1
TOTAL STAFF AS OF 31/12/2016	523
TOTAL AVERAGE ANNUAL STAFF 2016	571
including <b>148 Ph.D. students</b> and <b>100 post-doctoral fellows,</b> for a total of <b>248 people</b>	



### ARMINES. NETWORK PARTNERS

### **AiCarnot: Association of Instituts Carnot**

ARMINES represents Institut Carnot M.I.N.E.S within AiCarnot and has a seat on the Board of directors.

www.instituts-carnot.eu

### EARTO

ARMINES is one of the 350 members of the European Association of Research and Technology Organisations. www.earto.eu

### Réseau C.U.R.I.E. (CURIE network)

ARMINES is a member of the network which brings together stakeholders which promote French public research. www.curie.asso.fr

ARMINES is also a member of **ANRT** (National Technology Research Association), **EIRMA** (European Industrial Research Management Association) and **ASRC** (the source of innovation for industry).

# GOVERNANCE

### THE BOARD OF DIRECTORS

Robert Brunck, President Wladimir Mercouroff, Vice-president, Professor

### FRENCH GOVERNMENT REPRESENTATIVES

### **Michel Lartail**

Acting chairman of the innovation, competitiveness and modernisation section of the General council of the Economy, Industry, Energy and Technology - Ministry of the Economy, Industry and Digital Affairs

### Alain Dorison

École des Mines graduate, general council of the Economy, Industry, Energy and Technology - Ministry of the Economy, Industry and Digital Affairs

### **Xavier Montagne**

Assistant to the scientific director for the Energy, sustainable development, chemistry and processes sector - Research and Innovation Department - Ministry of Education, Higher Education and Research

### **ORGANISATIONS**

### CEA and Énergies Alternatives,

represented by Jean Therme, Special Advisor to the DRT and Managing Director for Renewable Energies reporting to the CEA General Manager

LCL, represented by Marc Seurret, Retail Development department

**Bpifrance**, represented by Nathalie Delorme, in charge of the technology transfer centre - Partnerships and Innovation ecosystems department

### SECTOR SPECIALISTS

### Maher Chebbo

Chief Commercial Officer at General Electric (GE) leading GE Global Power Digital Solutions

### Frédéric Feyel

Director of the Simulation & Modelling Department - Safran Tech

François Mudry Chairman, IRT M2P

### Jérôme Gosset

Senior manager of the hydro-Québec research institute (IREQ) - Technology Group, Varennes, Quebec, Canada

### FRENCH GOVERNMENT COMMISSIONER

### **Emmanuel Caquot**

Head of the supervising schools mission, General council of the Economy, Industry, Energy and Technology -Ministry of the Economy and Finance

### STATUTORY AUDITORS

GBA Audit et Finance, Paris

### THE MANAGEMENT TEAM



Patricia Renaud Director



Anne Frisch Deputy Director in charge of the business and finance department



Éric Weiland Deputy Director in charge of the contracts and development department. Deputy Director, Institut Carnot M.I.N.E.S



Valérie Tainturier Human Relations Director



Véronique Chapuis Legal Director



**Stéphane Heitz** Project Director

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Cover photo: The HEXCEL Chair team at MINES Saint-Étienne, which is involved in modelling and digital simulation for mastering the manufacturing through liquid n infusion of bigh performance comparis resin infusion of high-performance composite structures for aeronautics (Key moment on page 7).



60, boulevard Saint-Michel 75272 Paris Cedex 06 - France Tel.: +33 (0) 140 5190 50 Fax: +33 (0) 1 40 51 00 94 A list of our research centres is available at:

www.armines.net