
cetim
Innovating
in mechanical engineering
INSTITUT
CARNOT
Cetim

# Cetim support for the development and test of composites parts

**Dr Philippe CASTAING**
**Franck BORDELLIER**

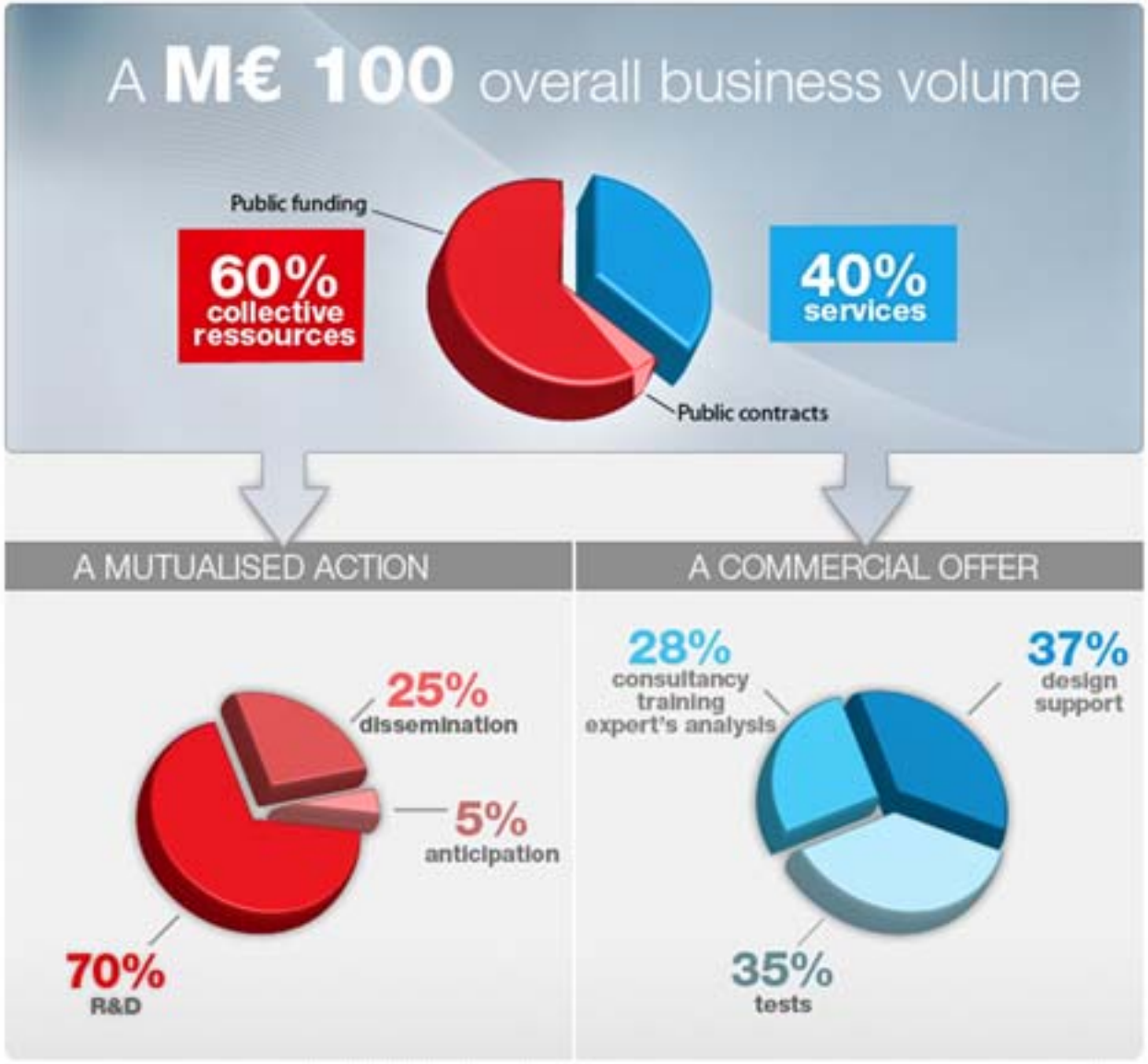
**Polymer & Composite Engineering Dpt**

# Technological institute of mechanics

*Steered by mechanical industrialists under the State's supervision*



Governed by articles
L342.1 to L342.13
of the French research code



# A regional, national, international actor

*The French mechanical centre close to its 7,000 subscribing companies*



Fondationcetim
sous l'égide de la Fondation de France

CETIM
CERTEC

cetim cermat

CTDEC

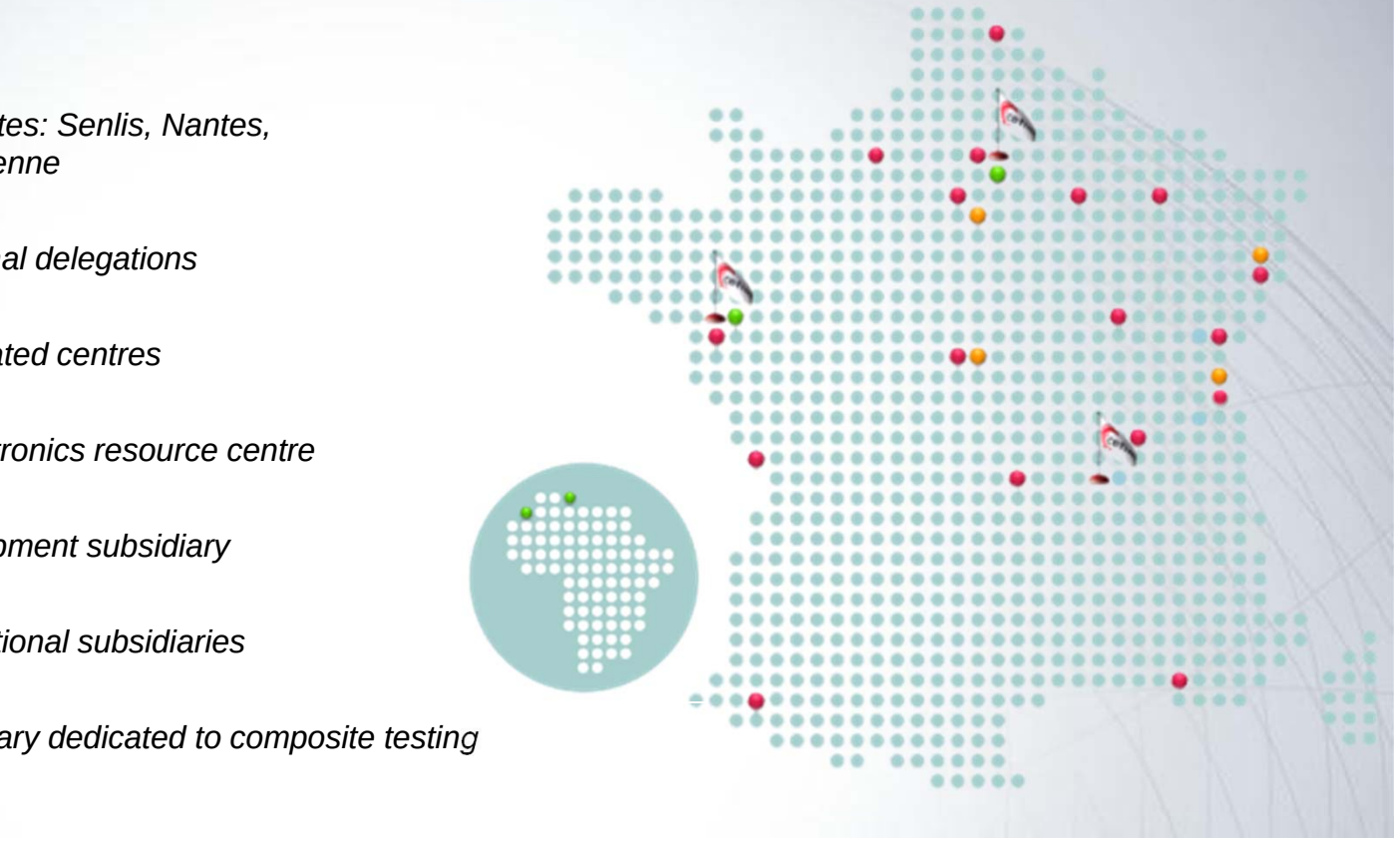
LRCCP
Votre partenaire polymère

cetimMaroc
Cetim Maroc développement

cies
Cetim international engineering services

Etim
COMPOSITES

- *3 main sites: Senlis, Nantes, Saint-Étienne*
- *16 regional delegations*
- *4 associated centres*
- *1 mechatronics resource centre*
- *1 development subsidiary*
- *2 international subsidiaries*
- *1 subsidiary dedicated to composite testing*



***Senlis***

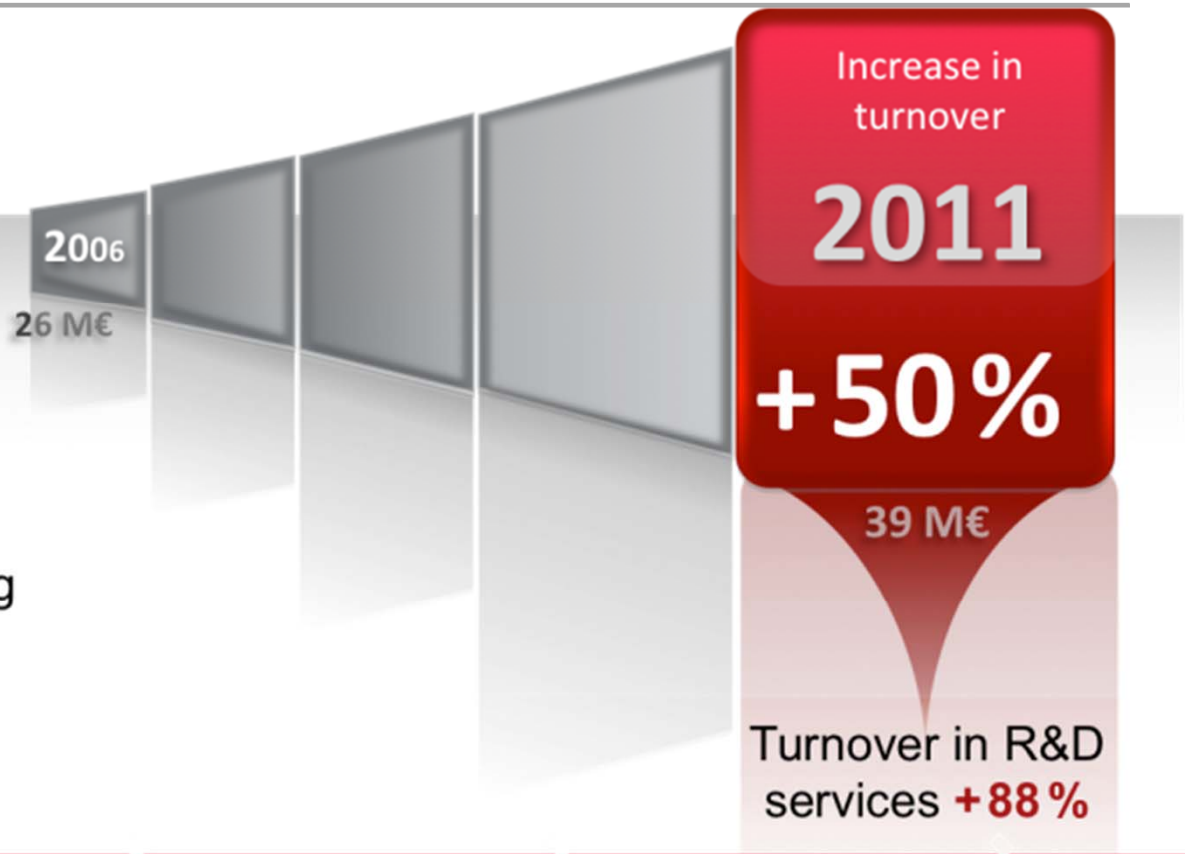
***Nantes***

***Saint-Étienne***

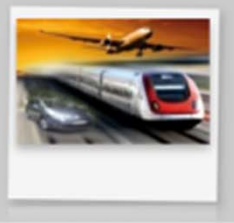

cetim

# A strongly growing service activity

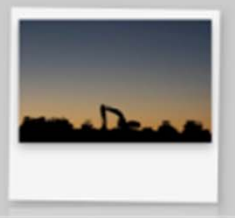
- Engineering, design support
- Tests, simulation
- Consultancy, expert's analysis, training




TRANSPORTATION | ENERGY | MECHANICAL COMPONENTS | SERVICES TO BUSINESSES | PRODUCTION OF EQUIPMENT

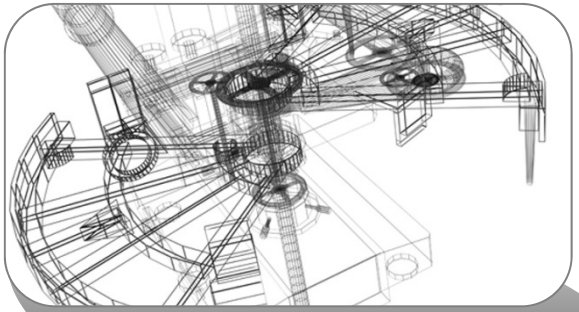






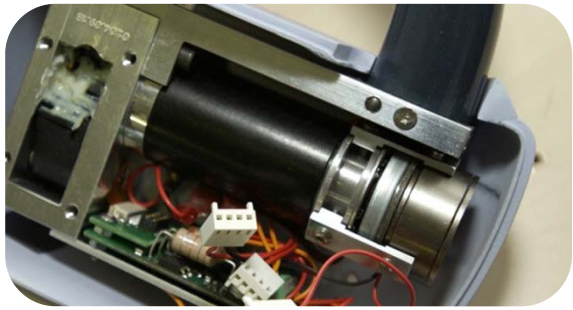
# Making technological choices for the future





**Design**
**Simulation Tests**

*Priorities*



**Mechatronics**
**Inspection**
**Measurement**

**4 technological areas**

**Materials - Processes**

**Sustainable development**

cetim

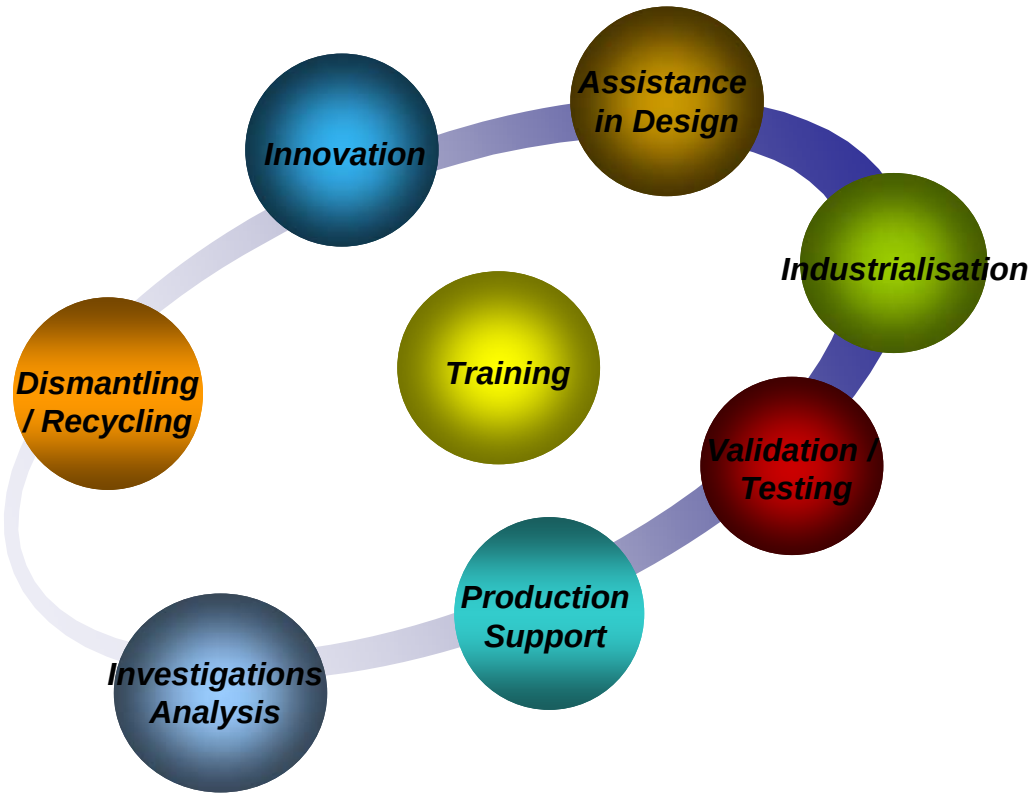
# *Polymer and composite material engineering*

***Our targets:***

*Become a major partner for* ***innovation and creation of value for R&T projects***

*Offer Cetim's Composites expertise on the entire chain of value,* ***"from innovation to operation" in order to develop product performance while controlling quality, cycles and costs***

# Our comprehensive offer




- ***Innovation:*** *Search for innovative concepts by creativity / joint-development workshops*
- ***Assistance in design:***
  *Design / redesign at a target cost*
- ***Industrialisation:*** *Development of thermoplastic / thermosetting composite parts (thermocompression, filament winding, RTM etc.)*
- ***Validation / Testing:*** *Research & Development tests on composite materials*
- ***Production support:*** *Series production follow-up tests (aircraft parts)*
- ***Investigations / Analysis:*** *Failure analysis, investigations of composite parts and paints*
- ***Dismantling / Recycling:*** *Ecodesign / recyclability studies / environmental impacts*
- ***Training:*** *Composite and elastomer training courses*

cetim

# Markets and references

## Aerospace industry

AIRBUS, ThalesAlenia Space, SAFRAN, ASTRIUM, EUROCOPTER, DUQUEINE, DAHER, S.A.B.C.A.

## Automobile industry

PSA PEUGEOT CITROËN, MGI COUTIER, Valeo, Autoliv, trèves, MECAPLAST GROUP, Visteon, faurecia, PLASTIC OMNIUM, SAINT JEAN INDUSTRIES, RENAULT

## Energy industry

stx Europe, EDF, ALSTOM POWER Hydro, SBM OFFSHORE, SBPI TRANSPORT DE FLUIDE, AREVA, eca, Alcatel-Lucent, PONTICELLI, Technip, DCNS, bôccard Alliance for success

## Mechanical industry

CRYOLOR, GM, FAUN ENVIRONMENT, KUHN, CLAAS, CNH, ALSTOM Transport, JTEKT ITEKT CORPORATION, Haulotte GROUP, MANITOU, cetim

# Our product: Product and process development



- **An organisation broken down into trades**

## DESIGN TRADE

*Definition of product requirements*

*Search for solutions*
*(creativity method, brainstorming, etc.)*

*Design of product parts / process*

*Product calculation / Dimensioning*

*Calculation for process validation / product optimisation*

## INDUSTRIALISATION TRADE

*Design and manufacturing of tools*

*Development of tools / process*

*Prototype testing and development*

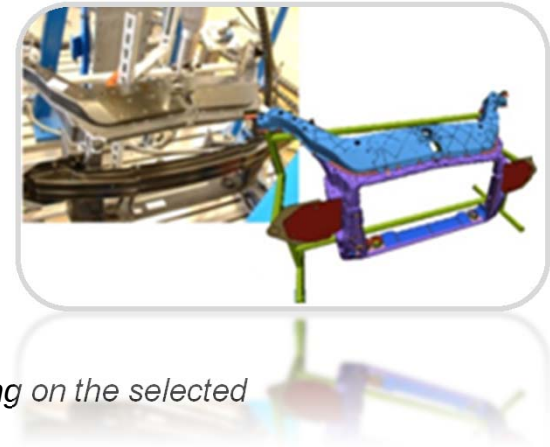
*Drafting the manufacturing file*

## MANUFACTURING TRADE

*Assistance in the technological change towards composite materials*

# Reference: Composite material solution pack

**Objective** : *Provide a technical and economic survey to a decision maker who wants to differentiate through innovation.*
**Deadline** : *12 weeks maximum*
**Budget** : *€ 30 to 50 K (eligible for Research Tax Credit).*
**Experience** : *More than 50 surveys carried out for the Automobile, Aeronautical, Energy and Mechanical sectors*



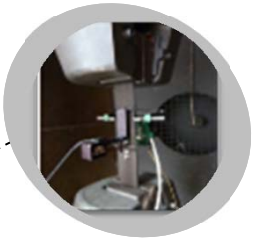
- ***1st step: technical survey***
  - *Consolidation of the functional analysis with the customer*
  - *Definition of the overall design of the product: design, materials and processes*
  - *Previous dimensional assessment*
  - *Weight survey*
  - *Identification of technological obstacles*
- ***2nd step: industrial scenario***
  - *Macroscopic elaboration of the manufacturing and inspection process layout, depending on the selected technologies*
  - *Production rate survey (cycle time)*
  - *Approach of the industrial scenario (workshop setting-up or subcontracting)*
  - *Identification of possible suppliers and subcontractors*
- ***3rd step: economic synthesis***
  - *Production cost related to material, manpower, inspection, etc.*
  - *Industrialisation cost corresponding to the various tools and to specific equipment*

cetim

# Our product: Testing


*Ageing, Humidity and Durability tests*

*Quasi-Static tests*



*Metrology*

*Creep tests*

*Characterisation of parts and materials*

*Determination of the behaviour laws*

*Correlation with numerical models*

*Physical and chemical tests*

*Crash tests*

*Vibration tests*

*Fatigue tests (LCF / HCF)*

*Impact tests*

# Our product: Failure analysis

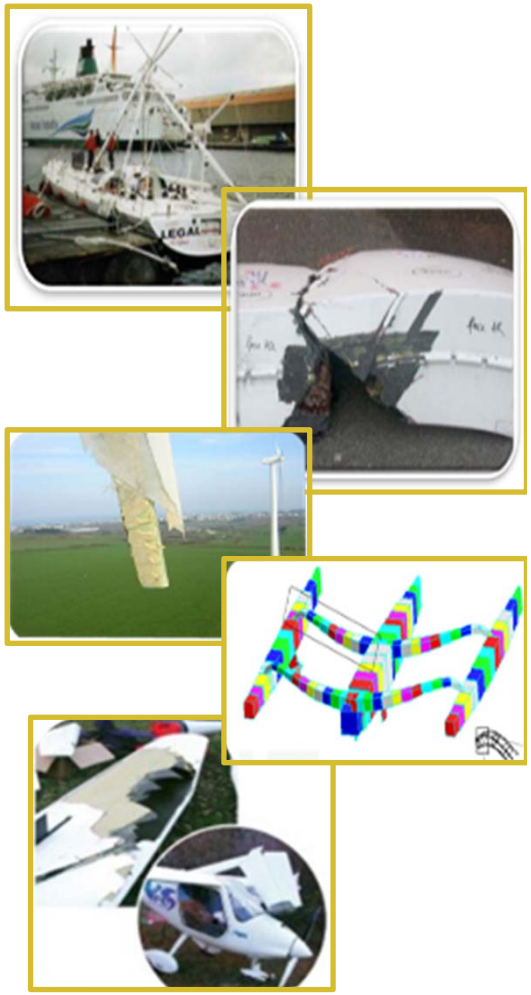
## Industrial – Legal investigations

### Stakes and objectives

- *Finding solutions to solve a problem (production downtime, major damage, after-sales return, risk of hazardous situation, etc.)*
- *Identifying the probable root causes of the failure of a system, a part or a material (polymers, composite materials, paints)*
- *Providing technical support to solve the causes and related disputes*
- *Consulting, training and preventing failures*

### Assets

- *Cetim puts at your disposal specific competences to deal with your problem*
- *ACQPA/FROSIO certified inspectors for on-site inspections*
- *Integrity and impartiality*
- *Confidentiality (NDA, since Cetim is classified as a “sensitive site” by the DCRI, the French central directorate of interior intelligence)*
- *Actions in France and abroad*
- *Experience of work in various industrial environments*
- *A well-proven approach*



# R&D projects and professional actions

***Marketing & Technological watch*** → ***Orientation to structural thermoplastic composites***

***Design***

- *Service life prediction*
- *Durability of structures and assemblies*
- *Crash and impact testing*
- *Probabilistic design*
- *Failure analysis, damage tolerance and harmfulness of defects*

***Manufacturing***

- *Development of RTM, forming / injection, pultrusion and filament winding processes*
- *Modelling of implementation processes*
- *Bonding and multi-material joining, welding of thermoplastic composite materials*
- *Machining / surface preparation / painting*

***New products***

- *Shape memory structures and their applications*
- *Damping composite solutions*
- *New joining technologies*

cetim

# Examples

## *Major project of high speed filament winding platform*

- ***Objectives***
  *Provide mechanical engineering industrialists with a development platform*
- ***Concept***
  *Develop the automated filament winding technology with laser heating system in order to reach a speed above 1 m/s with the laser so as to reduce costs*
- ***Partners***
  *CEA List and Le Ripault / Cetim*

## *Major project of high production rate pilot line*

- ***Objective***
  *Become the French reference composite material development centre for the automobile industry*
- ***Concept***
  *Develop a pilot line for manufacturing of composite and multi-material parts starting from the fibre and ending with the finished product, in order to achieve the Production Rate, Cost, Weight and Quality objectives which are specific to the automobile industry*
- ***Partners***
  *IRT JV, CRPDL, Technocampus, EMC2, ID4CAR, Cetim operator, Cemcat, Comp'inov , 3D Mat, etc.*

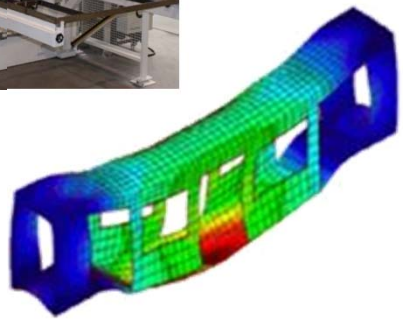
## *Major project of reference laboratory*

- ***Objective***
  *Become the European leader for mechanical and physical-chemical characterisation of composite materials*
- ***Concept***
  *Offer on a single place all the facilities and means for mechanical and physical-chemical characterisation of composite materials with a comprehensive range of stresses and parameters.*
- ***Partners***
  *Cetim: FCM, EPI, IPC, ECN ,etc.*

cetim

# Example: the “Composite Innovation OpenLab” Comp-Innov common laboratory





***Scientific and technological framework***

- *Implementation of composite materials*
- *Durability, reliability-based approach*
- *Damage tolerance*
- *Behaviour and modelling of assemblies and structures*

***Cooperation framework***

- *A shared common strategy*
- *Implementation of theses, master’s degrees, etc.*
- *Setting up of collaborative projects*
- *Resource pooling*
- *Shared equipment investment*
- *The same shared commercial offer*

ECN Centrale Nantes — ENS Cachan — CNRS INSIS

cetim

# Research to develop synergy

Tightness/sealing Laboratory in Nantes (France)

***The "Carnot" network*** *to extend the scope of R&D and promote partnership research:*
*€ 14 M – activity multiplied by two over 7 years.*

***25 theses*** *funded.*

***9 common laboratories*** *with universities and the CNRS (French National Centre for Scientific Research) in order to associate scientific research with technological innovation.*

***A foundation*** *to clear scientific and technological obstacles.*

***Projects funded jointly*** *with research operators.*

# A partnership action

***Cetim, deeply involved in collaborative research***

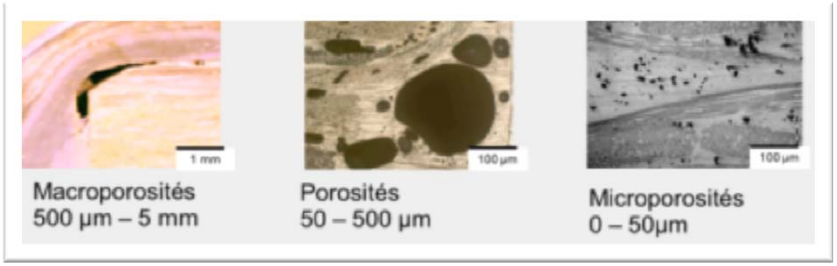
*More than 15 studies (theses, master's degrees and post-doctoral degrees) on various subjects:*

- *Durability, crash resistance of TP composite materials, forming of TP and RTM TP composite materials, Smart composite, multi-material joining*

- *More than 12 on-going collaborative projects on the following subjects:*
  - *Forming of TP composite materials*
  - *Pultrusion of TP composite materials*
  - *Welding of TP composite solutions*
  - *Multi-material bonding*
  - *Development of new 3D preforms*
  - *Durability of structures*

# Our resources

## *Our test and failure analysis resources*




### *Quasi-Static testing*

- *Quasi-static testing machines (from 10 kN to 1,300 kN)*
- *Impactor and impact tests*
- *Cold and hot tests (from -180° C to + 250° C)*
- *Video-extensometry, damage follow-up equipment (acoustic emission, etc.)*
- *Extended machine capabilities to characterise mass-distribution materials and very high technology materials*
- *Viscoelastic tests (creep, temperature)*
- *Creep testing machines (25 kN)*

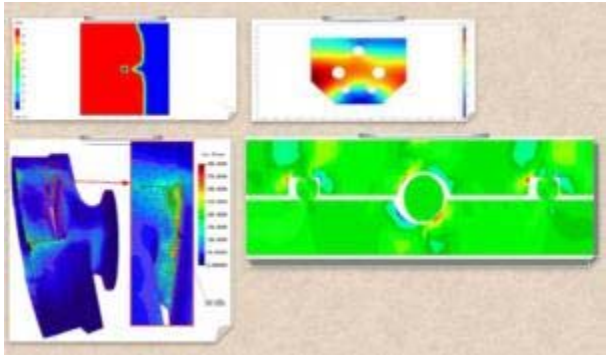
### *Physical and chemical analyses*

- *HPLC and GPC lines, Rheometers/DMA, FTIR microscopy, FTIR analysis, TMA, ATG / mass spectrometer, thermomechanical analysis, differential enthalpic analysis, etc.*
- *Paint film characterisation tests: bending, stamping, pendulum hardness, adhesion, colorimetry, salt spray, etc.*
- *Examination equipment: binocular magnifier, microscopes, scanning electron microscope, fractography atlas, etc.*
- *Ageing enclosures*

cetim

# Our resources

## Resources related to design



### Product simulation

- *CAD: SolidWorks, Catia V5*
- *Solid finite elements: Abaqus, SolidWorks Simulation, Cosmos/M*
- *Specific software programmes: Patran, Livemath, Matlab*

### Process simulation

- *Infusion and RTM injection simulation: PAM-RTM, MOLDFLOW*
- *Thermal Simulation: COMSOL - thermal simulation of tools and parts, optimisation of induction heating ROCTOOL system*

## Manufacturing resources

| | | | | | | |
|---|---|---|---|---|---|---|
|  | *Thermo forming* |  | *Induction heating of tools, Roctool system* |  | *Thermoplastic injection unit* | *Manufacturing of thermoplastic composite parts by thermal forming and injection* |
|  | *RTM* |  | *Infusion* | | | *Manufacturing of thermosetting composite parts by RTM injection and infusion* |
|  | *Thermo plastic pultrusion* |  | *Filament winding* | | | *Manufacturing of thermoplastic composite parts by continuous processes* |
|  | |  | |  | | *Assistance in the implementation and optimisation of painting workshops* |

# References

## Our qualifications

- COFRAC accreditation (Accreditation in accordance with ISO 17025: tests on composite materials). * 1-0037
- NADCAP Certification (Certification for tests on non-metallic materials, 17 tests accredited)
- Customer certifications:
  - Qualification as per Safran specifications
  - Qualification as per Airbus specifications

- Renault Accreditation: Our associated centre, (Cetim-Cermat) holds a Renault “Passenger Compartment Interior” self-approval for laboratory tests

# *Innovating*

## *in mechanical engineering*

INSTITUT CARNOT Cetim

cetim