RESEARCH AND DEVELOPMENT

Cetim's 2024-2027 research & development strategy

CETIM

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Foreword

With Cetim, the French mechanical engineering industry has acquired a shared research tool with a unique leverage effect.

Cetim is a repository of the knowledge of the mechanical engineering industry and is at the service of mechanical engineering companies. It is both a driving force behind innovation and a vehicle for the transformation of the mechanical engineering fabric, that will drive the energy and ecological transitions.
The Scientific and Technical Committee, made up of industrial manufacturers, instructing parties and academic partners, helps Cetim's Board of Directors to validate the R&D strategy.
We are attentive observers and we also ensure that Cetim will be at the forefront of interdisciplinary technological advances while remaining focused on the fundamentals of mechanical engineering. This is a challenge for the whole industry to move upmarket.

I encourage industrial manufacturers wishing to make an active and agile contribution to take part in Cetim's R&D projects... This is a guarantee that their needs will be listened to attentively and a privileged means of assimilating the results of the work.

Philippe Lubineau
Research Programs
Director

Editorial

**R&D is not a preserve...
at least not for Cetim**

The mechanical engineering industry is connected to all the other sectors which are suppliers of all markets. It is a major exporter (38.4% of export sales in 2023) made up of world-class companies and a dense network of small and medium-sized enterprises (SMEs)...
All these characteristics mean that the mechanical engineering industry plays a key role in structuring the French production system. Innovation is of prime importance, serving the goal of sustainable reindustrialisation.

Supporting and accelerating innovation within the mechanical engineering sector is a major challenge. It is also our purpose! But there can be no innovation in companies without rapid access to finalised R&D.

Every four years, in line with the objectives set by the Board of Directors, under supervision of the Scientific and Technical Committee (STC), we draw up a strategic R&D roadmap to equip the French mechanical engineering industry with the means to meet the demographic, ecological, health and social challenges of our time. This methodological approach spans nine months, involves consultation with industrial manufacturers and professional organisations, as well as the compilation of over 150 roadmaps, ensuring maximum relevance and efficiency. All this work is steered by the STC.

Over the years, we have enriched our strategy with over a hundred national and international scientific partnerships. These collaborations strengthen our R&D capacity and enable us to respond to industrial needs with in-depth and cross-disciplinary expertise.

This strategy is embodied in concrete projects, supported by an annual budget of 90 million euros. Because the role of an industrial technical centre like Cetim, which has also held the Carnot label from the beginning, is certainly not to operate in isolation. We are proud to actively involve 2,000 manufacturers in the implementation of these shared projects, not only by prioritising initiatives but also by contributing to the framing of the work. This win-win collaborative approach enhances the relevance, impact and effectiveness of our actions and enables technical insights and case studies to be shared.

Our role is not limited to simply producing knowledge. We are also committed to working alongside manufacturers in transforming the results of this R&D into their day-to-day operations, thereby fostering their ability to set all sectors in motion and to act continuously as a driving force behind the energy and ecological transition.
To date, over 12,000 companies have embarked on a tailored transformation and innovation cycle, showing the significant impact of our initiatives.

Our vision involves strengthening the competitiveness of the mechanical engineering sector, ultimately contributing to a more sustainable and resilient industry. Together, by combining expertise, R&D and collaboration, we are shaping the industry of tomorrow.

Mechanical engineering at the heart of industrial innovation

Mechanical engineering has stood the test of time and has always been one of the driving forces behind human progress. At the service of industry as a whole and present in all areas of the economy, mechanical engineering provides an ever-expanding range of new technologies. Industrial production goes hand in hand with mechanical engineering.

**"Mechanical engineering is all around us:
in every building that goes up,
in every switch we operate,
in every meal we eat;
in every journey we take,
in every course of treatment."**

Henri Morel,
President of the French Federation
of Mechanical Industries
(FIM)

From the extraction of raw materials to their distribution, from the design of products to their use and including their manufacture, processing and marketing, the mechanical engineering industry supports the 19 sectors grouped together within the National Industry Council (CNI), both as:

- A subcontractor in the supply chains, via the casting, forging, machining, forming, bar turning and service treatment processes;
- A manufacturer of production machinery and equipment, integrated components and subassemblies ("suppliers of solutions").

Thanks to its dynamic, high-performance regional ecosystems, the mechanical engineering sector plays a key role in the success of these industrial sectors. Innovative, responsive small, medium-sized and intermediate-sized enterprises contribute to the international success of France's most prestigious flagships (aerospace, energy, high-speed trains, etc.).

Present throughout France, mechanical engineering accounts for 10% to 20% of industrial jobs.

KEY FIGURES FOR MECHANICAL ENGINEERING

Leading **French industry** in terms of workforce

157 **billion euros in sales**

10,910 **companies having** more than 10 employees

Over **600,000** **employees**

Over **50,000** **recruitments** per year

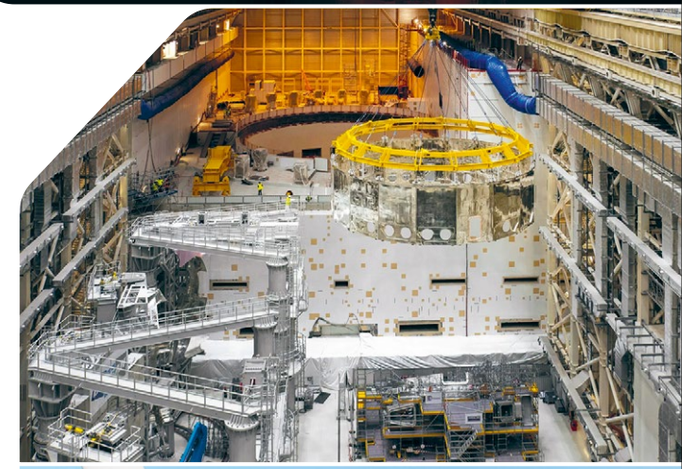
Because of this special position, mechanical engineering is the very basis of the French production system.

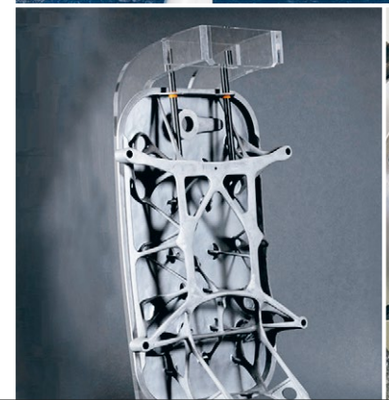
Strategic challenges facing the mechanical engineering sector

Since the mechanical engineering sector contributes both to the performance and frugality of industry and to the development of sovereign sectors, the challenges it faces represent a wider issue than just its core business.

The main challenges facing the mechanical engineering sector are as follows:

- making circularity and eco-design more accessible;
- anticipating raw material shortages;
- replacing the most hazardous chemical substances;
- bringing the best of digital technology (interoperability, AI, IIoT) to mechanical engineering companies while managing cyber risks;
- preparing mechanical engineering companies for the deployment of hydrogen;
- strengthening mechanical engineering skills to manage new materials, product innovations and process transformations.





Cetim: at the heart of **French mechanical innovation**

As a Research Technological Organisation (RTO) with a mission of general interest, Cetim brings the best of research to the mechanical engineering industry. Its 1,000 experts, doctors, engineers and technicians support companies in France and abroad, helping them to upgrade their products and transform their processes to meet the needs of the mechanical engineering industry and achieve the goals of France's industrial policy.

Cetim is a **research and knowledge dissemination organisation.**

As a reference centre for 17 mechanical engineering professions, Cetim is the repository of mechanical engineering know-how, which it constantly updates. It projects the mechanical engineering fabric, and in particular its many small and medium-sized companies, into a knowledge-based economy which is being structured on a global basis. In more concrete terms, Cetim defines its R&D projects with the professions, carries them out or has them carried out, and transfers the result to mechanical engineering companies, 95% of which are small and medium-sized companies.

Cetim's mission is two fold:

- Carry out work that makes advances in fundamental research operational, so that they are accessible to industry and enable the development of the fundamentals skills and the Key Enabling Technologies (KETs) of the mechanical engineering world;
- transfer knowledge and technological know-how to companies over the long term, to allow them to upgrade their production tools, products and surface.

Cetim is deeply rooted in the French territories (**11 sites in mainland France**) and boasts emblematic testing and appropriation platforms. It is a major player at the service of both companies and the French State, working with the French Regions and the leaders of the major sectors to rebuild our industries.

Cetim has also held a **Carnot Institute certification since 2006.** It has been awarded this label four times consecutively by the French Ministry of Research, in recognition of its ability to carry out R&D work with and for industrial companies.

// Cetim stands at the intersection of industry and accademia driving process in mechanical engineering though innovative solutions. //

Carole Gratzmuller,
Chairwoman of Cetim

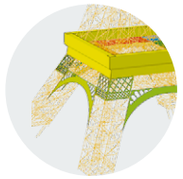
50+ YEARS OF EXPERIENCE TO SUPPORT MANUFACTURING INDUSTRY:

- Systems Performance **Mastering**
- Sustainable Industrial **Transformation**
- Materials-Products-Processes **Engineering**
- Cetim Academy® **Trainings**
- Failure **Analysis**

Safety, health, space, and so many other sectors... a few emblematic contributions of Cetim over the last 60 years

› 1985
1st prototype artificial heart in the world

In 1985, at the request of Professor Carpentier, Cetim produced the first prototype to be tested in animals. The first human implantation took place in 2015.

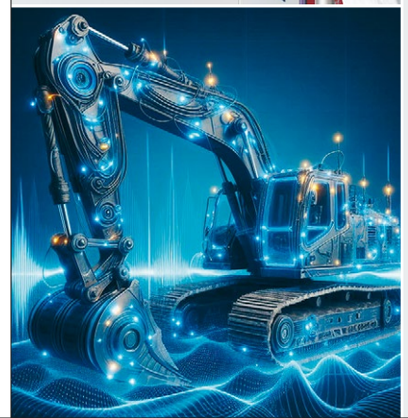


› 2015-2019
Securing the Eiffel Tower

The goal was to ensure the durability of the Eiffel Tower, using a dynamic model simulating the behaviour of the structure (effects of wind, snow, visitors, etc.) and integrating the condition of its 11,700 tonnes of metal, including paint and rivets.

› 2021-2022
Waterproofness of the Perseverance rover and in situ analyses of the Martian soil

The objective was to guarantee the waterproofness of the laser, the Perseverance rover's "eyes", and develop the technology for soil analysis, as part of a Carnot research partnership.



CETIM IN A FEW FIGURES

€ 180 M
of turnover

among which
€ 100 M
dedicated to R&D

70 %
of engineers, doctors and technicians

1,100
employees

soon
20 years
under the
Carnot label
(since the origins, 2006)

more than
6,000
member mechanical engineering companies

17
professional sectors covered

CETIM: A MEMBER OF THE CARNOT NETWORK FOR THE INDUSTRY OF THE FUTURE

Cetim is a signatory to the "Network of Carnot Institutes for the Industry of the Future" Charter which brings together the following Carnot Institutes around an ambitious project for our future:

- Carnot Cetim ;
- Carnot ARTS ;
- Carnot CEA-List ;
- Carnot CEA-Leti ;
- Carnot Chimie Balard Cirimat ;
- Carnot Ingénierie@Lyon ;
- Carnot Icéel ;
- Carnot LSI ;
- Carnot MECD ;
- Carnot MERS ;
- Carnot MICA ;
- Carnot M.I.N.E.S ;
- Carnot Télécom & Société Numérique.

For this network of Carnot Institutes, the aim is to conquer the sectors of tomorrow that will ensure France's industrial independence, its jobs and its place on the world stage, with "innovation", "reshoring", "sovereignty", "scaling up of new technologies" and "decarbonisation" being the key elements.

The network has agreed on two major objectives:

- Coordinating actions around 3 targets for the French Industry:
  - adding value to the production tool / operating site and its organisations, and contributing to decarbonisation through the use of "Industry of the Future" technologies;
  - designing and producing innovative and environmentally-friendly products that integrate new services;
  - promoting the emergence of a new French offer of "Industry of the Future" solutions, by involving all players in the value chain.
- Coordinating our actions around 4 major areas of innovation over the long term:
  - upmarket move for products;
  - smart industrial production system;
  - environmental and energy transition of factories;
  - putting people at the heart of organisation.

The strength of a **plural governance** structure that brings together many experts from the mechanical engineering sector

› Cetim's decisions and orientations are submitted to the Board of Directors

Cetim's administration is entrusted to a Board of Directors, whose members are independent representatives proposed mainly by the professional organisations representing the mechanical engineering industries, in addition to personalities and representatives of the French State.

› For the R&D choices: the Scientific and Technical Committee

Cetim's Board of Directors relies on the Scientific and Technical Committee (STC) to validate the R&D strategy.

Mechanical engineering companies
Representatives of employees of the mechanical engineering sector
Knowledgeable figures (R&D&I)
→ **Board of Directors**

Mechanical engineering companies
Representatives of employees and instructing parties
Heads of research laboratories
→ **Scientific and Technical Committee** → **Scientific Advisory Board**

STAKEHOLDERS

2,000 industrial companies take part in PTT/PSS [1]
Machining sector
Fluid equipment
Mobile machinery and systems
Machines and processes
Thin sheets and wires
Materials, transformations and treatments
→ **Committees and Sector Commissions**

› To prioritise and ensure the best complementarity of research projects: Sector Commissions and Programme Committees

The Sector Commissions bring together industrial manufacturers and representatives of professional organisations in the sectors concerned.
These commissions select the sector-specific studies to be conducted by Cetim.

› To monitor the quality of research work: the Scientific Advisory Board

To improve the scientific monitoring of its work, Cetim has set up a "Scientific Advisory Board" under the guidance of its Scientific and Technical Committee. The role of this Board is to provide an opinion on the quality of upstream R&D studies, especially those performed in joint laboratories between Cetim and other academic research players.

[1] Cross-Functional Thematic Projects (PTT) and Sector Strategic Projects (PSS), see page 25.

Our priority: meeting the **new challenges** facing the mechanical engineering world

At Cetim, we are convinced that the mechanical engineering industry holds part of the key to solving the major challenges we are facing. Our ambition is clear: contribute to an increasingly sovereign, positive and sustainable mechanical engineering industry, capable of assimilating the latest innovations to meet the new social and economic challenges.

To achieve this, Cetim's research activities cover all levels and dimensions of the mechanical engineering ecosystem. Cetim's R&D strategic priorities are thus designed to:

1 Cover the entire mechanical engineering process

From upstream to downstream of a mechanical engineering product, the need for R&D is everywhere

2 Address the concerns of the four sectors of the mechanical engineering industry

Manufacturers of production machinery and mechanical engineering equipment:

- Eco-design;
- Digital twins of machines;
- Electrification;
- Hydrogen;
- Transformation of machines using 4.0 technologies;
- ...

Manufacturers of components and subassemblies:

- Manufacturers of components and subassemblies:
- Carbon footprint;
- AI and its uses;
- Energy efficiency;
- New technologies in manufacturing processes;
- ...

Manufacturers of consumer products:

- Substances and impact;
- Food compatibility;
- Traceability;
- ...

Manufacturers of mechanical parts produced by casting, forging, machining, forming, bar turning, surface treatments, etc.:

- Automation and robotisation;
- Impact of regulations on the various trades;
- Digital transition;
- ...

3 Address the challenges expressed by the various customer markets of the mechanical engineering sector

These include:

Aeronautics

- Green aircraft;
- Alternative fuels;
- Innovative manufacturing processes;
- ...

Automotive

- Electric vehicle and its value chain;
- Environmental regulations;
- ...

Mining and metallurgy

- Electrification of processes;
- Carbon Capture, Utilisation and Storage (CCUS);
- ...

New energy systems

- Renewable hydrogen;
- Energy mix;
- Energy efficiency;
- ...

Nuclear

- Extension of the service life;
- New nuclear power plants;
- Safety;
- ...

"Industry of the Future" solutions

- Smart machines;
- Digital twin;
- Additive manufacturing;
- ...

4 Cover the innovation needs of the various departments and employees of companies

From the production plant through to use of the products, all departments are affected by the need to innovate. Here are a few examples:

Management

- Diversification and new markets for the energy and environmental transition;
- Corporate Social Responsibility (CSR);
- Digital transformation and data-driven supervision;
- ...

QSE department

- Digitisation and automation of testing;
- Monitoring of equipment and components;
- Energy optimisation of processes;
- ...

R&D, prototyping, design office and process planning departments

- Selection and implementation of materials and processes;
- Faster, more reliable design and validation cycles;
- Eco-design and low-tech design;
- ...

Production department

- Digital chaining of processes;
- Cognitive and physical assistance of operators;
- Machine interoperability;
- ...

Marketing and operations departments

- Functionality economy;
- Productive maintenance;
- Impact in variable environments (hydrogen, pressure, temperature, etc.);
- ...

Cetim's research ecosystem and its impact

Since mechanical engineering is a major exporter, its competitiveness can only be approached from a vision that is totally rooted in global competition. Cetim's strategic plan has been devised around this requirement, so that it can provide mechanical engineering manufacturers with the best technological advances in a knowledge-based economy that has also become global. Cetim would like to enhance its international R&D and technological partnerships by relying on the areas where it has sites or has expanded its operations (Europe, Asia, North Africa).

Cetim's international academic partnerships

UNIVERSITY	FIELD OF RESEARCH
Univ. Patras Univ. Harokopio	NDT Security / Env.

UNIVERSITY	FIELD OF RESEARCH
U. Southampton U. Newcastle IMechE Imperial College Open University	Fatigue & R. Stress Power Trains Acoustic & Vibration Composite Composite

UNIVERSITY	FIELD OF RESEARCH
Univ. Padova Polytech Milan	Fatigue & R. Stress Security / Env.

UNIVERSITY	FIELD OF RESEARCH
Tech. Uni. Prague	Mechatronics, acoustics

UNIVERSITY	FIELD OF RESEARCH
Uni. Of Porto	Power Trains.

UNIVERSITY	FIELD OF RESEARCH
Uni. Las Palmas Technalia	Mechanical Process NDT

UNIVERSITY	FIELD OF RESEARCH
TNO TNO	NDT Secirity / Env.

UNIVERSITY	FIELD OF RESEARCH
Energiatudomán yi Kutatókozpont	NDT

UNIVERSITY	FIELD OF RESEARCH
Uni. Tempere	NDT

UNIVERSITY	FIELD OF RESEARCH
KTH Winteria World Maritime Univ	Fatigue and welding Fatigue and welding

UNIVERSITY	FIELD OF RESEARCH
DMV TU Munchen Uni. Siegen Frauenhofer IPA Uni. Darmstadt TU Braunschweig Frauenghofer ILT FZI-Karisruhe IT Frauenhofer MPA BAM BAM TU Munchen	Fatigue & R. Stress Power Trains Mechatronics, acoustic Mechatronics, acoustic Mechatronics, acoustic Security / Env Mechanical Processes Security / Env. Sealing Technologies Materials & Surface Sealing Technologies Composite

UNIVERSITY	FIELD OF RESEARCH
DTI	NDT

UNIVERSITY	FIELD OF RESEARCH
Institut von Karman Institut von Karman SIRIS SIRIS Institut von Karman	Sealing Technologies Fluids & Flow Composite Mechanical Process Stimulation & Pres. Equipt

UNIVERSITY	FIELD OF RESEARCH
University College Dublin National University of Ireland Dublin	Machining 4.0

UNIVERSITY	FIELD OF RESEARCH
EIR ARGUE ARGUE ESA	Fluids & Flows Add. Manufacturing Materials & Surface Sealing Technologies

UNIVERSITY	FIELD OF RESEARCH
NTU NTU NTU NUS NUS	Add. Manufacturing NDT Fatigue & Residual Stress Materials & Surface Composite

UNIVERSITY	FIELD OF RESEARCH
MMU SIRIM SIRIM SIRIM SIRIM	Materials & Surface Add. Manufacturing Composite Industry 4.0 Fluids & Flows

UNIVERSITY	FIELD OF RESEARCH
HUCE Hanoi UTC Hanoi	Mechanical Processes Power Trains

UNIVERSITY	FIELD OF RESEARCH
Mahidol Uni. King Mangkut Uni.	Materials & Surface Metrology

UNIVERSITY	FIELD OF RESEARCH
OMM (university of Ljubljana, Sloveny)	Material Characterization

Legend

- FRENCH STRATEGIC PARTNERSHIPS
- PROJECTS PARTNERSHIPS
- INTERNATIONAL COMMON LAB
- OTHERS PARTNERSHIPS

UNIVERSITY	FIELD OF RESEARCH
SINTEF Sciences & Tech. NU	NDT Materials & Surfaces

UNIVERSITY	FIELD OF RESEARCH
Curtin Uni.	Power Trains

UNIVERSITY	FIELD OF RESEARCH
KIMM	Power Trains

UNIVERSITY	FIELD OF RESEARCH
ETS Montreal ETS Montreal Uni. 3 Rivieres	Power Trains Sealing Technologies Power Trains

UNIVERSITY	FIELD OF RESEARCH
KIMM KMTL JS of Material Sciences University Kyushu IHI Corp. University Kyushu University of Tokyo	Power Trains Power Trains, Composite Fatigue & Residual Stress Fatigue & Residual Stress Add.Manufacturing Hydrogen Hydrogen

UNIVERSITY	FIELD OF RESEARCH
KIMM KMTL JS of Material Sciences University Kyushu IHI Corp. University Kyushu University of Tokyo	Add. Manufacturing Mechanical Processes Add. Manufacturing Fatigue & Residual Stress Power Trains Sealing Technologies Fatigue

Cetim has set up several excellence-driven academic and technological partnerships in France and abroad: 10 joint laboratories / 7 technological platforms / a foundation to explore upstream research through high-level scientific projects / an agile network of scientific, technological partners (ONERA, CEA, Carnot Alliance for the Industry of the Future, etc). In addition, Cetim has been involved with the French Mechanical Engineering Association (*Association Française de Mécanique*, AFM) since its creation. All in all, this represents more than 1,000 R&D projects steered every year by many experts with dedicated technical resources.

10 joint laboratories shared with 22 partners, including:

- CETIMAT
- COMP-INNOV
- LAMA
- LAMECAS
- LAMFM
- LATEP
- LEDITH
- LERDED
- LUPPIAM
- TRANSMECA
- LEMCOS UMR 5259
- LABECAM

1 network of scientific and technological partners

A strategy that draws on all the **expertise of the mechanical engineering world**

To establish its R&D strategy, Cetim drew on various types of input data and conducted a structured "funnel" analysis in 6 steps:

1

Analysis of around one hundred French and international technological roadmaps and prospective roadmaps

These roadmaps are drawn up by major private firms, trade associations, research institutes, public bodies, etc. and cover three geographical levels:

- Regional, particularly through the roadmaps of the Regional Plans for Economic Development, Innovation and Internationalisation (French: *Schémas Régionaux de Développement Économique, d'Innovation et d'Internationalisation*, SRDEII);
- National, notably through the sector contracts of the French Industry Council (*Conseil national de l'industrie*, CNI), roadmaps of major R&D players and trade associations;
- International, with a number of "key technology" type studies carried out by major firms, or EU research framework documents.

Based on an analysis of these hundred or so documents, it was possible to identify five hundred technological building blocks or innovation topics. A second screening led to the selection of 120 topics, technological building blocks to be developed or existing technological building blocks to be integrated. Of these 120 topics, 75 were considered to have a strong medium-term impact on the French mechanical engineering industry. These topics have been categorised into five areas based on a mechanical engineering foundation. They cover:

- decarbonisation and circularity of mechanical engineering;
- sustainable materials for mechanical engineering, from the standpoint of development, characterisation and transformation processes as well as water savings;
- digital transformation of mechanical engineering;
- mechanical engineering in new energy systems, including nuclear power;
- mechanical engineering and low-carbon mobility;
- excellence and innovation in fundamental mechanical engineering.

2

Contribution of experts on major scientific issues

One of Cetim's strong points is its ability to bring together all its fellow and senior experts so that they formulate their own vision of the strategic needs in terms of R&D over the next few years. Their in-depth knowledge of the current state of research in a given field, and the potential it represents for meeting the challenges of an increasingly sovereign, positive and sustainable mechanical engineering industry, make them a key resource for defining today's major scientific issues. In this case, their analysis has allowed Cetim to identify:

- The scientific and technological expertise to be developed over the next four years with regard to the five fields resulting from the analysis of step 1;
- The essential mechanical engineering skills to be consolidated and the inflexions to be implemented.

3 FIM

Consideration of the visions of trade organisations

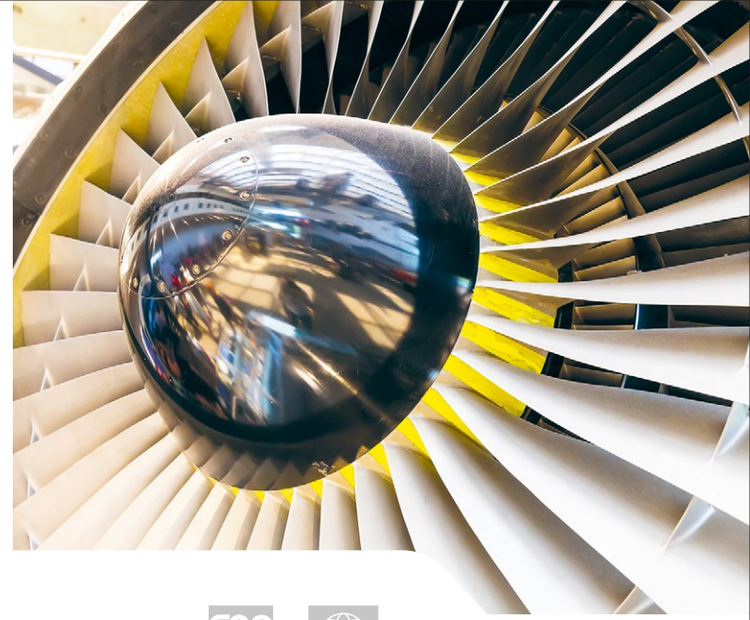
Another key source of expertise in the mechanical engineering world, which Cetim relied on to define its R&D strategy, was the trade associations, first and foremost the French Federation of Mechanical Industries (FIM). Discussions dedicated to the R&D prospects in this sector enabled us to identify with them current and future technological challenges.

The four sectors of the mechanical engineering industry represented through the trade commissions helped to identify the main technological topics of interest. In total, some thirty topics emerged, including:

- energy saving,
- artificial intelligence and digital transition,
- decarbonisation of industry,
- development of hydrogen or nuclear power,
- as well as issues related to reliability and regulations,

All these topics were raised several times by all business sectors.

[Find out more on the 4 sectors of the mechanical engineering industry on page 10]



4 UNM CEN ISO

Consideration of the major issues of standardisation

Defining subjects with prospects for the mechanical engineering industry cannot be done without first considering the major issues of standardisation that this sector has to face. To this end, work has been carried out with the French Standardisation Association for Mechanical Engineering (in French: *Union de Normalisation de la Mécanique*, UNM) to take into account the issues of standardisation on a European and international scale (CEN-ISO).

The main topics identified for pre-standardisation studies and/or standardisation work with management or strong involvement of Cetim's experts are:

- Environment and circular economy: studies aimed at accelerating the roll out of cross-cutting concepts, requirements and methods within mechanical engineering "product" standards;
- Additive manufacturing: studies aimed at continuing the introduction of standards, along with specific support for taking over the CEN and ISO secretariats in this field;
- Digital company: studies on innovative themes that can be supported by standardisation to accelerate their dissemination and adoption by industrial manufacturers, for example: digital twin, digital simulation, domain ontologies, IoT, machine-to-machine communication protocols;
- AI and cyber security in connection with machine safety: studies aimed at simplifying the integration of the requirements of the new Machinery Regulation 2023/1230 into nearly 550 mechanical engineering standards;
- Hydrogen: studies aimed at speeding up the integration of requirements associated with hydrogen into mechanical engineering standards (production equipment, transport, storage, distribution);
- Welding and pressure equipment: studies aimed at strengthening the normative initiative capacity of mechanical engineering manufacturers in the nuclear sector.

5

Consideration of the technological needs of the customer sectors defined by the National Industry Council (CNI)

Among the 19 industrial sectors defined as strategic for France by the National Industry Council (French: *Conseil National de l'Industrie*, CNI), Cetim met with several of them to identify their specific technological needs as "customers" of the mechanical engineering sector.

This work helped consolidate the technological needs, in particular for the following sectors:

- aeronautics;
- automotive;
- renewable energy (excluding nuclear power);
- oil and gas;
- nuclear power.

6

Consideration of the business development needs of the Strategic Business Units

Cetim manages and maintains cutting-edge expertise in the various key areas for industrial manufacturers of the mechanical engineering sector through each of its three Strategic Business Units (Performance of Systems, Materials / Products / Processes, and Sustainable Transformation). These Strategic Activity Departments have set up a development vision in line with Strategic Business Units.

These visions include, for their scope of reference, a value chain of scientific and technical trade skills to be consolidated and/or acquired:

- reliability-based design;
- evaluating the performance of mechanical engineering systems;
- analysing and predicting the behaviour of mechanical engineering systems;
- making good use of materials;
- adapting processes to societal needs;
- designing in response to mechanical engineering and environmental issues;
- digitising for sustainable industrial transformation;
- developing industrial performance;
- supporting environmental transition.

A strategy centred around two sections

PRIORITIES OF CETIM'S 2024-2027 R&D

1 + 2 + 3 + 4 + 5 + 6

Inflections + Fundamental mechanical engineering topics

To accelerate R&D momentum

- Decarbonization & water saving
- Circularity & sustainable materials
- Digital transformation
- Energetic systems
- Low-carbon mobility

to ensure that key knowledge is consolidated or maintained over time

- Design, size, optimise
- Manufacture
- Test, monitor, validate

Point by point, Cetim's R&D strategy from 2024 to 2027

5 inflections in direction + fundamental mechanical engineering topics

Accelerate R&D momentum

Decarbonization & water economy

Energy management (optimisation, nature) and adaptation of mechanical engineering processes, components and machines to the energy mix and the reuse of water.

Optimised performance of **fluid systems** for the CCUS (Carbon Capture, Utilisation and Storage) sector.

Surface engineering and simulation to optimise the water and energy efficiency of mechanical engineering equipment and components.

Circularity & sustainable materials

"Materials" databases for reducing environmental footprint.

Characterisation of the **criticality of materials and substances**, search for substitutes.

Contribution of **digital metallurgy** to the development of new materials.

Biomimicry for sustainable mechanical engineering products.

Adapting transformation processes to new material grades (**recycled materials, substitute materials, green alloys, etc.**).

Eco-design extending the useful lifetime of components and systems.

Digital transformation

Digital chaining of mechanical engineering production and manufacturing processes.

In-line inspection and testing.

Digital twins of components and smart machines (multi-physics simulation, interoperability, 5G, generative AI, use of data).

Qualification of **metal additive manufacturing** technology and design optimisation / functionalisation.

Multiphysics approaches and Virtual Testing for design.

Energetic systems

Behaviour of materials and systems in **hydrogen, cryogenic and corrosive environments**.

Extension of service life (including reuse) of components and equipment (instrumentation and data analysis, etc.).

Low-carbon mobility

Methodologies to characterise and optimise the performance of mechanical engineering systems with regard to the specific aspects of **new uses such as electric mobility.**

Weight reduction and new features of parts through the optimisation of materials / products / processes.

Consolidate knowledge

Design, size, optimise

Physical properties, **behaviour laws**, knowledge and characterisation of metallic and non-metallic materials, mechanics of complex systems.

Predicting performance through robust and safe design: **correlation between calculations and tests** on products and systems, digital chaining, multi-scale dimensioning.

Contact mechanics.

Hydraulics Pneumatics, Mechanics.

Fluid mechanics.

Understanding **vibratory and acoustic behaviours**, reducing phenomena, signals processing, dynamics of systems and structures.

Manufacture

Improved and optimised performance and **efficiency of manufacturing, transformation, assembly and treatment processes** from the design of parts through to industrial control (metallic materials, composites, functionalisation and integrity of surfaces, automation, etc.).

Metallurgy (solid state / liquid state).

Regulatory developments.

Test, monitor, validate

Development of advanced methods and resources for **characterising materials** (metals, composites, glass, etc.), systems and equipment.

Damage analysis (defects, corrosion, fatigue, etc.).

Multiphysics instrumentation and metrology and associated signal processing.

Monitoring of components and systems (SHM).

Non-destructive testing.

From the field, **answers** to the most **concrete concerns**

Cetim never loses sight of the concrete concerns of departments in the field and ensures that each strategic priority covers needs wherever they may be. Here are a few examples:

R&D, prototyping, design office and process planning departments

Some questions:

- **Selection and implementation of materials and processes?**
- **Faster, more reliable design and validation cycles?**
- **Eco-design and low-tech design?**
- **Design for lean manufacturing?**
- **Design optimisation: topology, multi-physics?**
- **Predictability of performance?**
- **New alloys? Green steels?**

Appropriate strategic priorities:

- “Materials” knowledge
- Digital metallurgy
- Biomimicry
- Multi-physics approaches and Virtual Testing
- Surface engineering
- Contact mechanics, fluid mechanics, Hydraulics Pneumatics Mechanics

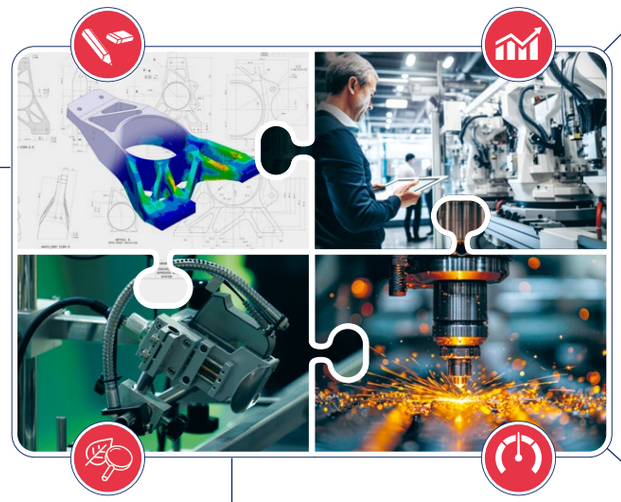
Management

Some questions:

- **Corporate Social Responsibility (CSR)?**
- **Digital transformation and data-driven supervision?**
- **Carbon border adjustment mechanism?**
- **Generative AI and retention / development of know-how?**
- **Diversification and new markets for energy and environmental transition?**
- **Regulatory and normative developments?**
- **New core businesses?**

Appropriate strategic priorities:

- New uses, such as electric mobility
- Fluid systems
- Regulatory developments
- Extension of service life
- Weight reduction and new features
- Eco-design



QSE Departments

Some questions:

- **Digitisation and testing automation?**
- **In-line process inspection?**
- **Monitoring of equipment and components?**
- **Environmental footprint and declaration?**
- **End-of-life management and recycling techniques?**
- **Substitution solutions for regulated substances?**
- **Energy optimisation of processes?**

Appropriate strategic priorities:

- Characterisation of materials
- Criticality of materials and substances
- Energy management
- In-line inspection / testing
- Non-destructive testing
- Multi-physics instrumentation

Production

Some questions:

- **Improvement of capability and productivity?**
- **Cognitive and physical assistance of operators?**
- **Control of production processes and resources?**
- **Control of production processes and resources?**
- **Digital chaining of processes?**
- **Automation and robotisation?**
- **Machine interoperability?**

Appropriate strategic priorities:

- Recycled materials, substitute materials, green alloys, etc.
- Efficiency of manufacturing, transformation, assembly and treatment processes
- Digital continuity
- Digital twins
- Metal additive manufacturing

Operation

Some questions:

- **Predictive maintenance?**
- **SHM / Monitoring?**
- **Guaranteed facility service life and safety?**
- **Through-life support?**
- **Requalification?**
- **Impact in variable environments (H2, pressure, temperature, etc.)?**
- **Functionnal economy?**

Appropriate strategic priorities:

- Behaviour in H2 and cryogenic environments and in corrosive medium
- Behaviour laws
- Correlation between calculations and tests
- Vibratory and acoustic behaviours
- Monitoring
- Damage analysis

For **faster** transformation

Either alone or in partnership with other players, Cetim has the ability to propose solutions tailored to every mechanical engineering company, depending on its size, level of technological maturity and sector of activity. This means implementing a seamless continuum of various types of actions, from upstream to downstream, to foster transformation. This continuum consists of three main components.

From the point of view of mechanical engineering manufacturers
This continuum of R&D actions allows mechanical engineering companies to have direct access to:

- dedicated knowledge, know-how and tools based on advanced technologies and/or mechanical engineering fundamental skills;
- business utilities and databases to respond more effectively, for example, to the needs of regulations and/or the consolidation of know-how;
- emblematic platforms/ equipment and demonstrators for assimilation and decision-making support;
- scientific/technical documents and experts to support standardisation;
- technological resources for assimilation and decision-making support that are not accessible on a company-by-company basis;
- training in current and future technological and digital developments.

A CONTINUUM OF R&D AND TRANSFER ACTIONS, FROM UPSTREAM TO DOWNSTREAM TO FOSTER THE TRANSFORMATION OF THE MECHANICAL ENGINEERING SECTOR

Cetim's cooperation with academic laboratories to refine the knowledge resulting from scientific work and make it transferable to industrial manufacturers.

Sector actions, which provide trades with the knowledge, tools and methods developed upstream. This is the field of application of Cetim's Cross-Functional Thematic Projects (PTT) and Sector Strategic Projects (PSS).

Collective actions: a continuum to foster the transformation of the mechanical engineering industry

Appropriation steps to transform the industries and support companies that have the best level of maturity, with these three major tools:

- Quatrium platforms;
- Carnot contractual research;
- standardisation, in conjunction with UNM, a significant driver of transfer and competitiveness.

Main research partners

CENTRALE NANTES · CIRIMAT Toulouse · CNRS · ECAM Lyon · ENISE · école normale supérieure paris-saclay · université PARIS-SACLAY · IMT Nord Europe · INSTITUT P' · INP Toulouse · INSA · IRT M2P · isae ENSMA · MINES Douai · MINES ParisTech · MINES Saint-Étienne · ARTS ET MÉTIERS ParisTech · isae supméca · UNIVERSITÉ DE NANTES · UNIVERSITÉ TOULOUSE III PAUL SABATIER · Université de Poitiers · VON KARMAN INSTITUTE · utc SORBONNE UNIVERSITÉ

Produce knowledge

Via

- Watch
- Exploratory research
- Mechanical engineering fundamentals

By relying on 10 joint laboratories

- Find new resources in a global knowledge economy
- Strive towards incremental progress

Adapt and share knowledge

Via

- Business Tool and technological documents
- Databases
- Demonstrators

By relying on our Cross-Functional Thematic Projects (PTT) and Sector Strategic Project (PSS)

- Assimilate and derisk innovations
- Coordinate technological communities (RD-LinkIM)

Help develop standards needed by the mechanical engineering industry

With

CEN · ISO · UNM

By relying on Cetim's 300 experts who are members of standardisation bodies.

- Support innovation and the creation of a trusting framework that is essential for the market

Make transformation a reality

Via

- Partnership R&D
- Adoption of new technologies
- Training

And our network of centres, laboratories, platforms and demonstrators.

- Transform the largest number of companies
- Assist the emergence of national champions

CARNOT · QUATRIUM · CETIM ACADEMY · bpifrance

R&D actions for knowledge dissemination

Cetim's approach to the effective transformation of the French mechanical engineering industry is to build a broad continuum of R&D actions. This continuum offers industrial manufacturers a complementary range of research, development and innovation services along with access to knowledge and technologies. These services necessarily include a generalist component, but can also be tailored to the individual needs of each industrial manufacturer.

From the most general to the most specific aspect, technological information is shared or transferred through:

- the *Mécathèque* (digital library for mechanical engineers);
- technical days, conferences;
- a question/answer service accessible to all subscribers;
- support for SMEs moving towards the industry of the future, including familiarisation with 4.0 technologies, through several methods:
  - 30 user paths for better familiarisation with the results of R&D actions around the themes of the Cross-Functional Thematic Projects / Sector Strategic Project through the RD linkIM collaborative platform;
  - implementation of various approaches (awareness raising, diagnosis, support for implementing at least one brick of the reference base for the Industry of the Future) on the Quatrium platforms;
  - training, market services.

The community of Cross-Functional Thematic Projects / Sector Strategic Projects through the RD-LinkIM platform

When it comes to involvement in R&D actions, nearly 2,000 industrial manufacturers participate in the Cross-Functional Thematic Projects / Sector Strategic Projects, thereby illustrating the interests of the topics and the attractiveness of the implementation methods. As a matter of fact, the participation of manufacturers is essential to ensure the vitality of the R&D action.

To enhance the assimilation of collective results, participation in the Cross-Functional Thematic Projects / Sector Strategic Projects takes place directly on a dedicated online platform called "RD-LinkIM" ("IM" stands for "mechanical industry"), which allows each participant to join communities. In concrete terms, RD LinkIM simply enables any industrial manufacturer who connects to it to:

- bring together in one place all the key information on a given theme (innovative technologies, performance and experiments, events, new products / services or players in the field, etc.);
- take advantage of a closed space, reserved for Cetim members, to discuss an industrial issue in complete confidence.

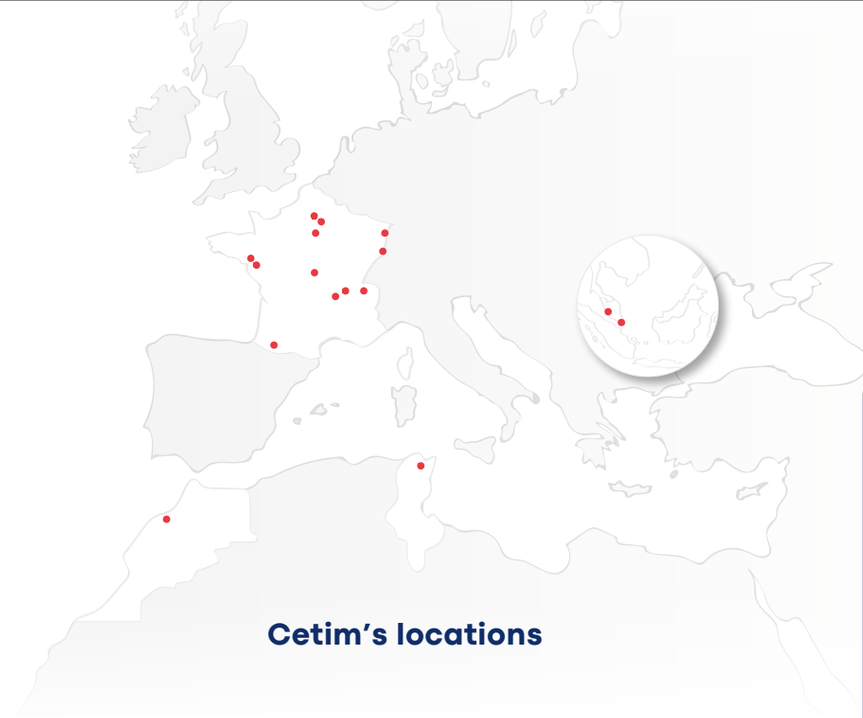
The challenge of mass accessibility

Every year, Cetim reaches more than

60 %
of member companies (70% over two sliding years). For example, several thousand documents are downloaded from the *Mécathèque* every year.

5,000 trainees
and nearly
4,000 companies are supported every year.

150,000
employees of the 6.000 Mechanical engineering industry compagnies are concerned with Cetim activities and require Cetim's support.



Cetim's locations

20
Main locations
France & Worldwide...

4,000+/year
Active clients
in 83 countries

1,100
Employees

+50 PhD students
per year

180 M€
Annual Turn Over

+300 published works
(Scientific papers, technological studies, conferences proceedings...)

20%
Export turnover

Standardisation with UNM for the competitiveness of the mechanical engineering industry in France and abroad (CEN - ISO)

FIM recognises that standardisation, particularly at an international level, is a key factor in the competitiveness of companies. As such, FIM expects significant support from Cetim on standardisation, especially in the following aspects:

- supporting industrial mechanical companies with its experts, in France, Europe and internationally;
- conducting pre-standardisation technical studies.

QUATRIUM
Réseau d'accélération

Cetim's Quatrium platforms

In order to enhance the impact of collective actions, Cetim's Quatrium acceleration platforms [1] are the gateways for small and medium-sized industrial manufacturers to receive tailored support in their transformation towards the industry of the future and their energy and ecological transition. This support is referred to as "support to the last mile".

In this process, Cetim draws on all its technological and production resources to offer industrial manufacturers the most relevant transformation points, depending on their expectations and the specific characteristics of their companies.

In the subsequent consulting phase, Cetim assists manufacturers with the design, preparation and implementation of the transformation, while helping them to identify and then organise their contacts with solution providers and lastly to derisk their investment. The key stages of this phase are the specialised diagnosis, the action plan, the selection of solutions and industrial production, which often goes hand in hand with a training component for the company's teams.

[1] Co-financed by the French State and local authorities in various French regions.

The **example** of **additive manufacturing**

Whatever the level of maturity of an industrial company on an issue related to mechanical engineering, Cetim's collective actions are broken down in such a way to allow the company to find answers to its concerns, upgrade its skills and thus render the decision-making process easier regarding its own transformation process.

"I would like to learn more and gain some insight"

Cetim's assets

I can get access to feedback from industrial companies.

Available tools

- Vast digital library
- Thematic working groups with shared results
- Demonstrators

"I would like to roll out a solution in my workshops"

Cetim's assets

Cetim helps me to secure the various steps of my project.

Available tools

- Experts and equipment to define integration parameters
- Simulation with suppliers of machines and materials
- Training

"I would like to receive technological assistance"

Cetim's assets

I manufacture one of my products with assistance from experts.

I receive personalised support to structure my project.

Available tools

- Shared resources and additive manufacturing advisors
- Programmes dedicated to a number of sectors (defence, energy)
- Industrial transformation experts

"I would like to innovate on my products to become a leader"

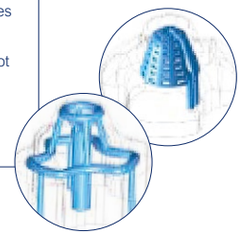
Cetim's assets

I have access to an innovation ecosystem.

I take part in standardisation* work relevant to my sector.

Available tools

- Introduction to mechanical engineering start up companies
- Research contract with Cetim Carnot Institute or other Carnot Institutes to help me innovate
- Access to Cetim's pre-standardisation* work

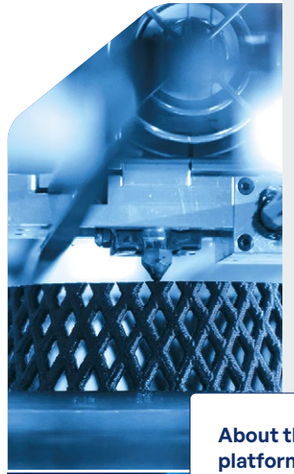


WORDS FROM MANUFACTURERS

Additive manufacturing as part of Cross-Functional Thematic Projects

"We were given the opportunity, as part of a Cross-Functional Thematic Project, to study the possibility of using additive manufacturing to produce a part that is usually mass-produced by machining. The idea was to determine whether it could be validated using new technologies. Cetim's experts provided us with assistance, from the design and simulation phases through to resistance testing at maximum pressure and at cyclic pressure of the parts produced by additive manufacturing. This assistance also included an economic analysis to compare the costs of the two processes. This allowed us to establish our position with regard to these new, fast-developing technologies."

"Within the framework of a Cross-Functional Thematic Project, we submitted a rather complex concrete case. It involved a small part used in the aerospace industry. Our collaboration with Cetim's engineers was very successful and they quickly understood the purpose and specific features of this part. They worked on the production of this part by metal additive manufacturing until they reached the technological limits. As a result, we made great progress in understanding the possibilities and the geometric control we needed to acquire with regard to our application."



About the Printing Bourges platform

"Without Printing Bourges, the unit price tag per machine is so high, and what's more, in a market that is not yet sufficiently mature, that I would never have considered starting to mass-produce parts by additive manufacturing. Thanks to this consortium, this is now possible."

"Today, we are about to start an industrial additive manufacturing production process. Together with Cetim's experts and the instructing parties with whom we work, we are considering manufacturing parts for programmes which, in five to ten years, will be completely mature."

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