

Welcome to C-TEC, Constellium Technology Center



C-TEC, Voreppe / France

C-TEC is Constellium's Technology Center, a leader in research and technology for aluminium products and related solutions. C-TEC has a global reach, being operated by professionals from over 22 countries and connected to all Constellium businesses and sites worldwide, as well as to a network of renowned academics.

C-TEC is at the heart of Constellium's innovation process – a global sector leader for a broad scope of markets and applications, focusing in particular on automotive, aerospace and packaging. In addition, C-TEC is:

- Delivering through best-in-class R&D a stream of **sustainable, innovative, value-adding solutions** to Constellium and our customers.

- Developing options for future **business growth** and leading a **Digital@Constellium** initiative.

- Maintaining **technology networks** in our key, shared processes (recycling, casting, fabricating), to ensure **best-practice sharing** and excellent **knowledge and talent management**.

▲ INNOVATION BEYOND MATERIALS

Whilst new products and solutions are imagined and incubated in our labs, C-TEC does not stop there. C-TEC benefits from a unique set-up in the industry, with prototyping capabilities at industrial scale both for the Constellium Group's processes with, for example, a full-scale plate and billet casting installation within the new Airware® casthouse, and for our customers' processes.

For example, our automotive stamping press can form parts with dimensions representative of mass production, and our canmaking tools can produce beverage cans to test new designs.

Thanks to this "lab to industrial scale" approach, innovations are fully tested to ensure they can be produced at the best quality, cost and time for our customers.

Customers also call upon C-TEC's simulation and numerical modelling capabilities, to help develop and design their products, using our metal. Thanks to a unique set of tools, numerous options can be quickly tested. This reduces development time and ensures very short time to market.

We innovate beyond materials for our customers.

Welcome to C-TEC,
welcome to innovation at Constellium

C-TEC

Constellium Technology Center

Constellium's innovation engine

C-TEC

Key facts and figures

Locations



22
Nationalities



243
Full-time employees



Over 200 patent families
and trademark

22* patents filed in 2018

Core competencies & special equipment

- ▶ Recycling and molten metal processing
- ▶ Casting and solidification
- ▶ Physical and mechanical metallurgy
- ▶ Surface treatment, coatings and corrosion
- ▶ Data science, artificial intelligence, IoT
- ▶ Process modelling, digital twins (rolling, finishing, extrusion)
- ▶ Product modelling and design
 - Integrated metallurgical modelling of alloys
 - Structural application design, e.g. aerospace
- ▶ Joining & forming



- ▶ Materials characterization & testing, chemical analysis and microstructural characterization, e.g.
 - Non-destructive, phased array ultrasonic testing
 - Large scale tensile and fatigue testing rig (2500 kN)
 - Field Emission Gun Scanning Electron Microscopes (FEG-SEM)
- ▶ Prototyping at industrial scale, e.g.
 - Friction stir welding
 - Breakthrough Airware® pilot casthouse
- ▶ 3D printing

Innovating for our strategic end markets

▲ AEROSPACE

Where innovation takes flight

Global leader in:

- Aerospace plates
- Aluminum-lithium flat rolled products and extrusions
- Fuselage sheets



With the help of C-TEC's key competencies and equipment, Constellium offers innovative, high performance products and manufacturing services that bring performance and cost benefits to aerospace companies of all kinds – whether they build commercial aircraft, military aircraft, or work on space programs.

Our plates, sheets, extrusion and precision sand casting aerospace products are used for a wide range of applications such as bulkheads, fuselage shells, wing skins, stringers, door frames or engine gearboxes.

▲ AUTOMOTIVE

Helping to drive the future

- A global leader in Crash Management Systems (CMS)
- Leading position in Europe in Auto Body Sheet



Constellium's advanced aluminium solutions, designed in C-TEC Voreppe & Plymouth and/or in Brunel, help global automotive manufacturers produce lighter, safer, and more fuel-efficient vehicles, as well as electric vehicles with greater range.

Automakers turn to Constellium for a wide range of applications, including car body closures, Crash Management Systems, Body-in-White structural components, battery enclosures, chassis and mechanical parts, heat exchangers, and functional surfaces for interior and exterior design.

▲ PACKAGING

Creating out-of-the box solutions

- Global leader in closure stock
- Leading positions in Europe and in North America for can body stock



For the packaging market, C-TEC is partnering with key customers to develop and industrialize innovative value-adding solutions. Research activities include: the development of thinner sheets to lightweight can body/end stocks, Drawn and Wall Ironed (DWI) aerosols & adaptation of an existing alloy to the specific needs of the new aluminum bottle. We also bring innovative aesthetic and functional attributes to aluminium closures.

In parallel C-TEC is contributing to optimize Constellium and customer manufacturing processes to make our aluminium solutions the best choice for their packaging applications.

Reducing global carbon footprint remains a key target in this market as in others. In this context, C-TEC is developing sorting and recycling technologies to expand our end-of-life scrap sourcing.

▲ OTHER MARKETS

C-TEC is also deeply involved in developing the next generation of products and processes for Constellium's other markets, in particular: Transportation (trucks, boats, rail, leisure vehicles), Industry and Defense, Heat Exchangers and Specialties (cosmetics, decorative parts...).

▲ ADDITIVE MANUFACTURING

C-TEC develops innovative high performance powder and wire alloys specifically designed for additive manufacturing, in close collaboration with customers. Additive manufacturing offers new opportunities and huge freedom of design for geometries which were previously impossible to produce.

Driving manufacturing excellence

TECHNOLOGY

Strong technology networks allow us to maintain and develop a high level of process expertise, and to roll out Best Practices, regarding CASTING AND RECYCLING subjects - such as molten metal safety, casting days, refractories, etc. - and ROLLING AND FINISHING subjects, such as hot and cold rolling, or continuous annealing line.



The Technology teams' core missions also consist in:

- ▶ Developing and industrializing new proprietary technologies – e.g. Airware® slab and billet casting, new DC casting mold, proprietary dual-jet waterhole mold with and without graphite insert, EMC electromagnetic casting, Batscan, patented CWS system for can and automotive, internal rolling oil formulation, online rolling models, new induction system tandem mill in Issoire plant, etc.
- ▶ Providing dynamic product and process plant support – e.g. see photo: widest aerospace DC cast mold size in Issoire plant for aerospace sheet production.
- ▶ Achieving step changes in process efficiency through accelerated processing or leaner process routes.

A steady pace of industrialization, combined with a comprehensive Techno Watch department give birth to five to ten new products and processes each year on Constellium's production sites, bringing new value to customers (e.g. Gripster®, enhanced Alplan, Securalex® High Strength, battery box...). Among our tools: a wide knowledge base including research reports and plant practices or trial notes and real time dashboards to benchmark process performance or follow new product characteristics during the ramp-up phase.

DIGITAL MANUFACTURING

Constellium is exploring opportunities for tomorrow's production using Digital Manufacturing ("Industry 4.0"). The key concept behind Industry 4.0 is the combined impact of multiple digital technologies, such as smartphone/tablet technology, the Industrial Internet of Things, cloud computing, Big Data and analytics, manufacturing simulation (with Digital Twin systems for example), augmented reality, and autonomous/collaborative robots. Our new Digital@Constellium core team includes specialists in sensors, networks, mobile devices data handling & analytics and artificial intelligence.



Working closely with manufacturing engineers, the Digital team is delivering projects to improve our operations in several domains:

- ▶ Safety: improving the efficiency of our Leadership Safety Tours using smartphone/tablet technology; camera-based system to alert forklift drivers and pedestrians of potential danger.
- ▶ Maintenance: data-driven systems to predict stoppages before they happen.
- ▶ Efficiency: metal traceability solutions such as RFID or QRCode readers to reduce inventory and metal costs, automation of certain tasks using collaborative robots.
- ▶ Quality: linking manufacturing process history to product quality data for reduced scrap rate and better, more stable products.

Innovation at our core

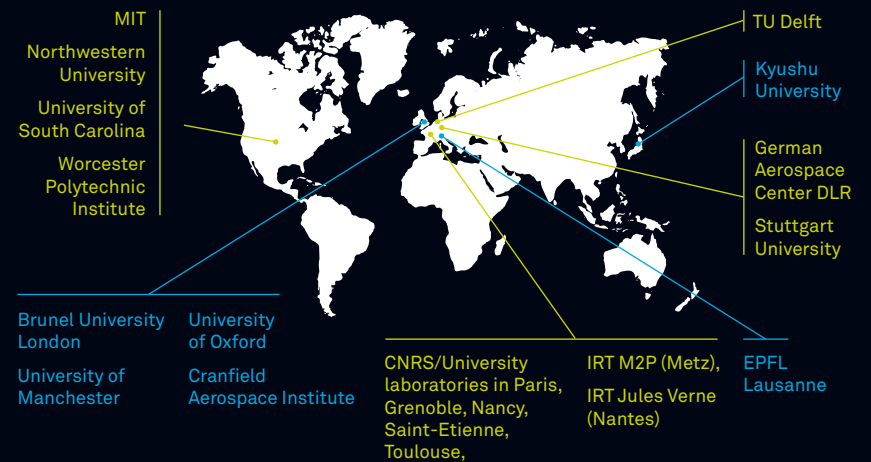
Our ambition is to be our customers' premier choice for innovative, next generation aluminium solutions in all the markets that Constellium is serving.

Recent Constellium innovations

	2018	Ultralex® AUTOMOTIVE
Airware® 2065/2076 Wing Stringers AEROSPACE	2018	
	2017	Airware® 2074 Fuselage AEROSPACE
AA7160 Plates AEROSPACE	2017	
	2017	Securalex® UHS AUTOMOTIVE
Kool X® Light Evaporators AUTOMOTIVE	2017	
	2016	Modalex® AUTOMOTIVE
Aeral® PACKAGING	2016	
	2015	Formalex® Remote AUTOMOTIVE
Billet Casting for Airware® AEROSPACE	2015	
	2014	Kool X® Exhaust Gas Recirculation Loop AUTOMOTIVE
HSA6™ CMS* Technology AUTOMOTIVE	2014	
	2014	Securalex® HS AUTOMOTIVE
Dokima® INDUSTRY	2013	
	2013	Gripster® TRANSPORTATION
Keikor® ARMOR	2013	
	2013	Staybright® AUTOMOTIVE
Formalex® Plus AUTOMOTIVE	2013	
	2012	Strongalex® AUTOMOTIVE
Securalex®, Surfalex® AUTOMOTIVE	2010	
2010, 2012, ...		Airware® AEROSPACE

*Crash Management System

Our International Scientific Council & collaborations



International Scientific Council

In 2013 we created the International Scientific Council of Constellium to nurture and broaden our perspective on emerging domains, key drivers, and technological trends related to our strategic activities. The council comprises five academic members from laboratories and universities around the world.

Our innovation teams at C-TEC and Plymouth work closely with the International Scientific Council to identify trends and upcoming opportunities. They provide us with high level advisory support and recommendations regarding R&D, approaches to innovation, research collaborations, and enriching our scientific network.

For example, in recent years the council has advised us on the "aluminisation" trend in the automotive market, as automakers seek out the benefits of lightweighting for electric and hybrid vehicles. We consulted the council about 3D printing and additive manufacturing, particularly in the aerospace industry, where we are partnering with several major manufacturers and suppliers. And as Industry 4.0 becomes a reality, the council has helped guide our decisions on using big data, the internet of things, and autonomous robots to maximize performance.

University partnerships

Constellium maintains scientific partnerships - many of them long-term - with approximately 50 of the most prestigious universities and laboratories around the world.

These include:

- ▶ **USA:** MIT, Northwestern University, University of South Carolina, Worcester Polytechnic Institute
- ▶ **UK:** Brunel University London, University of Manchester, University of Oxford, Cranfield Aerospace Institute
- ▶ **France:** CNRS/University laboratories in Paris, Grenoble, Nancy, Saint-Etienne, Toulouse, IRT M2P (Metz), IRT Jules Verne (Nantes)
- ▶ **Germany:** RWTH Aachen, German Aerospace Center DLR, Stuttgart University, Dresden Technical University, Paderborn University
- ▶ **Switzerland:** EPFL Lausanne
- ▶ **The Netherlands:** TU Delft

Customer Collaboration

Constellium's engineers and technicians work together with our customers to design and make cost-effective products and processes that correspond perfectly to their needs. Some of Constellium's most exciting innovations have come out of these collaborations.

Constellium's Chief Research & Technology Officer on innovation for our customers



Jack Clark
Senior VP,
Manufacturing Excellence
Chief Research & Technology Officer

▲ Why is C-TEC so special in the aluminium industry?

Constellium's R&D center has state of the art capabilities which allow our researchers to continuously innovate to meet our customers' needs and drive the future growth of Constellium. More importantly, Constellium's technical experts represent the best and brightest minds in the aluminum industry. Our team is constantly working on product and process innovations that will advance the use of aluminium in our key markets.

▲ What are the next big innovation challenges for your industry?

In aerospace, composites continue to pose a threat. However, we believe aluminium has significant potential to remain the material of choice through new alloys and innovative processing solutions. In automotive, the big opportunity is the impressive demand and ramp up of aluminium for this industry. We have always believed that this day would come, and now aluminium for the auto mass market is becoming a reality – at an accelerated pace. Our latest alloys already offer increased strength such as Strongalex@Plus and Securalex@HS for structural and crash applications together with HSA6 extrusion-based crash management systems. The challenge is to continue to increase formability, strength and energy absorption while meeting all the other technical requirements competitively. Light weighting and recyclability are the key drivers.

▲ What are other, longer term megatrends that you are looking at?

We continue to look at multi-material solutions, where aluminium is one part of the equation and is combined with other materials. This will enhance properties and create new applications. 3D printing / additive manufacturing is also an area of great interest. With our extensive knowledge of aluminium metallurgy, we are developing next generation powders for 3D printing. Last but not least Constellium is taking large steps to aggressively implement a Digital strategy that will accelerate innovation for new products and processes, thereby allowing C-TEC to meet our customers' needs at a faster pace.

C-TEC

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