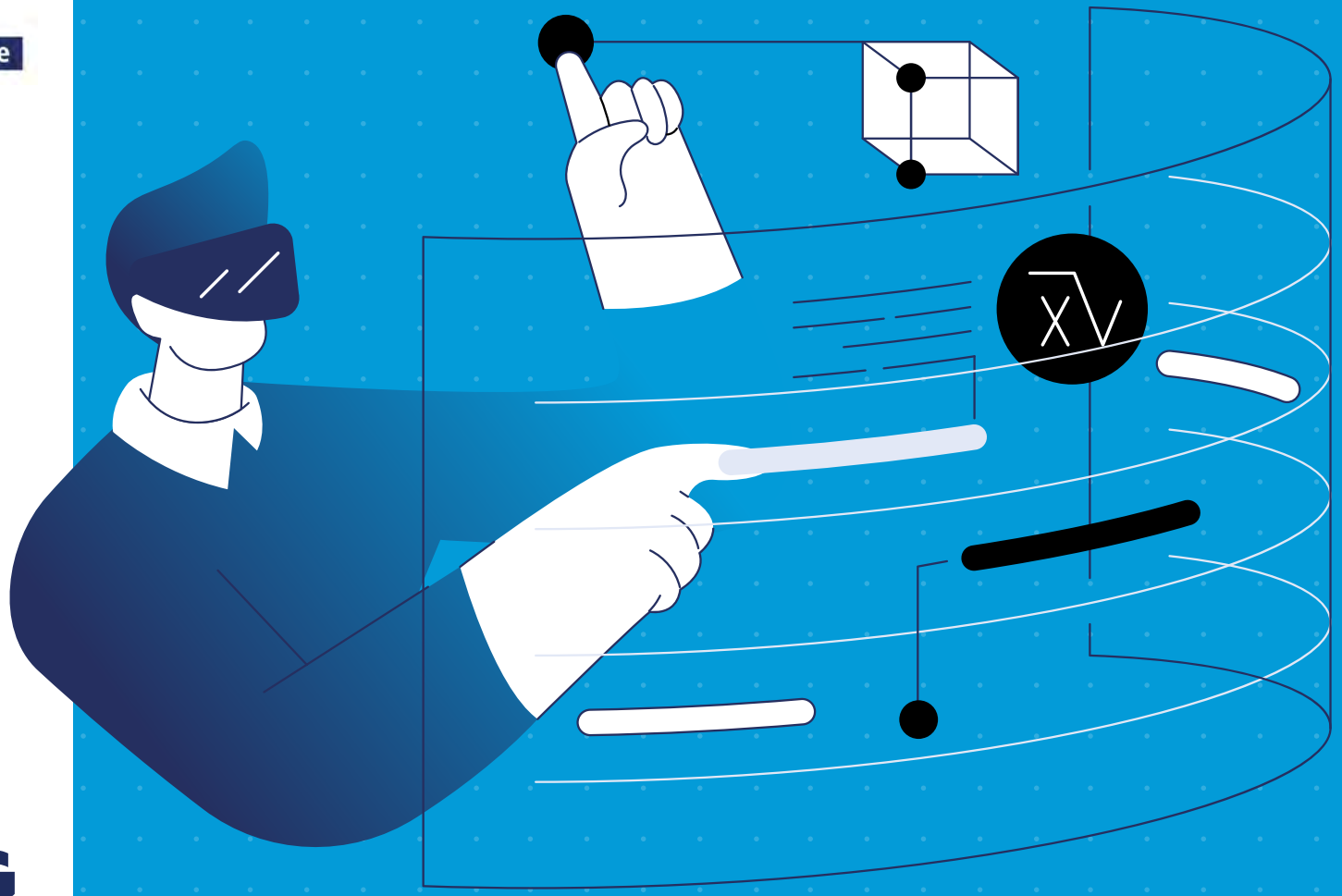
INSTITUT CARNOT
Télécom & Société numérique

RÉPUBLIQUE FRANÇAISE
Liberté
Égalité
Fraternité



2022-2023
ACTIVITY REPORT

SUPPORTING THE DIGITAL TRANSFORMATION FOR THE INDUSTRY OF THE FUTURE

About Carnot TSN

EDITORIAL

WORKING FOR THE FUTURE OF TELECOMMUNICATIONS

François Pineau

Director of Carnot TSN, Director of Projects, Strategic Marketing and Technology Intelligence at Institut Mines-Telecom

Over the past 10 years, many events have shown us the crucial challenges that face our country and the fragility of the French development model on the international stage.

The COVID-19 crisis demonstrated the inability of France, homeland of Louis Pasteur, to develop a timely, competitive vaccine, as well as the country's reliance on active pharmaceutical ingredients from Asia and surgical masks from industrial facilities in China.

The military conflict in Ukraine and the resulting geostrategic consequences on access to natural and energy resources helped plunge the nation into great uncertainty last winter, with often tragic consequences for France's self-employed workers and small and medium-sized businesses.

For more than 20 years, our specialists in geostrategy and economic intelligence have warned us against the loss of our sovereignty, describing a trap that would inevitably close around us. However, it wasn't enough to drive us to react in time to prevent predatory acts and the loss of our power in a number of sectors. The topic of sovereignty is everywhere now, becoming an essential component of all the political, social and economic challenges that face France in the future. While the French government seems to have taken the measure of the situation with its "France 2030" investment plan, political, institutional and socioeconomic stakeholders must drastically step up their efforts.

What can be done?

Of course, politics must play a role, whether nationally or internationally, to first secure access to the resources we need for production, or even just to live.

But by betting on our remaining strengths and mobilizing our efforts, humbly and without preconceived notions, we can regain sovereignty over the next 10 years. So of course, let's count on tourism, promote agriculture, expand our luxury crafts and restore our gastronomy to its former glory, but please, let's also use our brains to reindustrialize France. For this, we need to shift immediately to **a systemic approach at both the macroeconomic level,** to understand the links and trends between sectors and better focus state aid, **and the microeconomic level**, to provide players in the real economy with a favorable environment to grow.

Carnot Télécom & Société Numérique (TSN) intends to play a leading role in this area by forging close, long-term ties with business. Our researchers are already working with manufacturers to **expand their capacities for innovation,** offering top-quality R&D in 5xG in areas such as antennas, architecture, orchestration, cybersecurity, energy efficiency for systems, predictive maintenance, AI-optimized network resources, IoT, and digital twins. Now, we must boost our efforts in the various standardization committees like 3GPP, IUT and ETSI if we want to be able to one day roll out a European sovereign mobile network infrastructure. This rise in power through standardization is at the heart of the two key structural programs co-led by Carnot TSN on behalf of the French government, **the 5G PEPR and FRAMExG,** which involve almost all the country's forces in academic research.

Carnot TSN boasts **scientific excellence in all the fields related to digital technology**, from component manufacturing to use case studies. For example, there are three high-stakes national projects with a strong bearing on our sovereignty, that offer great opportunities for our researchers and a solid basis for our country's reindustrialization:

- **The Industry of the Future**, where industrial organization and the tools of production are moving steadily towards a greater symbiosis with digital technologies,
- **Healthcare**, where digital technologies allow for amazing progress in diagnosis and treatment,
- **Mobility on land**, where digital technology will not only allow us to develop self-driving cars but will also help us create an optimized, interconnected network for transporting people and goods in the years to come.

If we want to recover our sovereignty, laboratories' research will need to be more heavily involved in innovation in large companies as well as in medium, small, and even very small businesses. Here in France, will we succeed in creating the right conditions to convince our socio-economic fabric to see the environmental transition as an opportunity instead of a constraint?

Finally, will we manage to establish technological sovereignty in fast-growing fields? At Carnot TSN, our researchers have long been working on topics like artificial intelligence, blockchain and Web3 technologies and quantum computing. Let's not take 20 years to wake up!

CONTENTS

CARNOT TÉLÉCOM & SOCIÉTÉ NUMÉRIQUE

FRANCE'S LEADING PUBLIC R&D PARTNER SPECIALIZING IN DIGITAL TECHNOLOGY

The Carnot Institutes are groups of research teams working on the same topic and coming from several public institutions.

The Carnot label was created in 2006 as a label of excellence awarded by the French Ministry of Higher Education, Research and Innovation to foster partnership-based research, research work lead by public laboratories in partnership with socioeconomic stakeholders such as businesses.

INSTITUT CARNOT Télécom & Société numérique

Carnot Télécom & Société Numérique brings together 11 research establishments of excellence.
It is the first Carnot Institute specializing in digital science and technology at the national level.

See Carnot TSN in video

As a key player in R&D and digital innovation, Carnot TSN makes it easier for business to access the skills of public research laboratories with a structured, targeted research offer that is easy to implement and adapted to the needs of each company.

Thanks to its research teams and technological platforms, Carnot Télécom & Société Numérique works with companies of all sizes on the technical, economic and social implications of the digital transition.

An accelerator of the digital transformation

Carnot Télécom & Société Numérique brings together laboratories and research teams at 11 establishments of research excellence: a network of components with strong links to the local community and easy access to business.

Carnot TSN, a guarantee of excellence in partnership-based research since 2006

Carnot Télécom & Société Numérique is France's leading Carnot Institute in "information and communication sciences and technology".
With over 1,900 researchers - more than 200 more than the previous year - Carnot TSN focuses on the technical, economic and social implications of the digital transition. In 2020, the label was renewed for the fourth consecutive time, demonstrating the quality of the research and innovations achieved through collaborations between researchers and companies.

Find out more

Our areas of scientific and technical expertise to help companies of all sizes to face the challenges of the digital transition

- Networks & the Internet of Things
- Big Data & IA
- Cybersecurity
- Industry of the future
- Smart Cities
- Smart mobility
- Environment
- Energy systems
- Digital health

2022 KEY FIGURES

OUR STAFF

139
post-docs

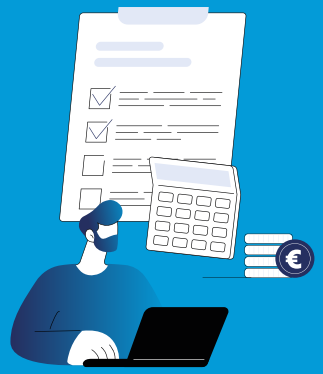
414
researchers and faculty members

1,178
PhD students (including 230 CIFRE)

203
research engineers and technicians

ECONOMIC DATA

Consolidated research budget
€112 mil



Partnership-based research income

€51 m
from direct contracts with businesses

€40 m
from contracts financed for agencies

€3 m
from technology transfers

COMPONENT LABORATORIES

11
component entities

29
joint laboratories with businesses

43
industrial chairs

68
technology platforms

SCIENTIFIC PRODUCTION

INNOVATION AND TRANSFER

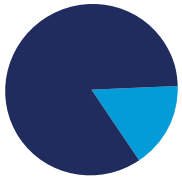
82
new priority and software patents in 2021

90
inventions declared

43
companies created during the year

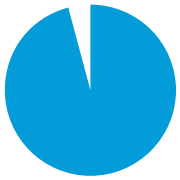
PROJECTS AND PARTNERSHIPS

More than 1,046 companies supported in their research and innovation projects
Carnot Telecom & Société Numérique is committed to intensive bilateral contract research with industry, signing a growing number of R&D contracts every year.



84%
of partnership-based R&D focused on the development of France's regions

16%
of R&D serving international companies



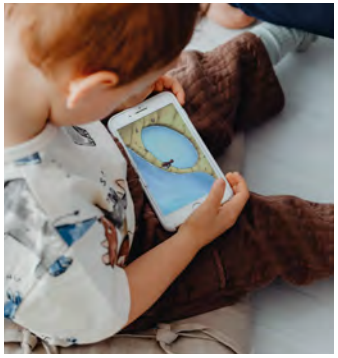
96%
companies satisfied

1,081
contracts were signed

736
direct contracts with a socioeconomic stakeholder

172
France agency collaborative projects

133
European collaborative projects



SEPTEMBER 2022

A study on minors' personal data

Protecting minors' personal data is a sensitive issue in legislation on digital technology, including in the United States, where record fines were handed out to major tech companies for breaking the law. With support from Carnot TSN, researchers such as Vincent Lefrere from IMT Business School looked at the factors that influence the collection of children's data, such as company size and country of origin. Their study lasted three years, covering 27,000 applications developed in 127 countries. It shows the positive effect major platforms' policies can have and the decisive role of legislation in countries where development takes place, especially Europe and the United States.

Read the article

DECEMBER 2022

The "Strengths of Polymers and Textiles" symposium

Carnot TSN is taking part in this convention dedicated to the benefits of polymers and textiles for the healthcare sector, organized by SFIP (Société Française des Ingénieurs des Plastiques) and TECHTERA (the French textile industry competitiveness cluster). Three main themes are on this edition's agenda: innovation, regulations and user expectations, and sustainable development

Read the article

KEY EVENTS

NOVEMBER 2022

2022 IMT-Académie des Sciences Awards

The winner of this award from Institut Mines-Telecom (IMT) and Académie des Sciences is a researcher whose initiatives have allowed for exceptional progress in optical engineering and robotics : Jean-Louis de Bougrenet de la Tocnaye, the professor heading the IMT Atlantique Optics Department, is also the manager of the Arago platform, which holds both the Platform IMT and Carnot Télécom & Société Numérique labels. A "Prix Espoir" was also given to Silvère Bonnabel, associate researcher at the Robotics Center and professor at MINES PSL, in recognition of his work combining mathematical theory and industrial applications in the field of automation.

Read the article

NOVEMBER 30, 2022

The "Beyond the Mobile Phone" Conference

This year's event, supported by Carnot Télécom & Société Numérique in partnership with EURECOM, France Brevets, IMT and Qualcomm, is dedicated to 5G and Intelligent Edge.

Read the article

JANUARY 2023

IMT and Carnot TSN, winners of the "prematuration-maturation" call for proposals

Read the article

The FRAMExG project, led by IMT and Carnot TSN, is one of the 17 winners of the "prematuration-maturation" call for proposals under the France 2030 investment plan targeting the innovation cycle to boost jobs and spur inventions and transfers of technology. This project aims to bring breakthrough 5G-6G technologies to maturity and transfer them to the socioeconomic sector.

The "Data Science and Artificial Intelligence" Chair

Read the article

With the support of Carnot TSN, this industrial chair at Telecom Physique Strasbourg and ICube Strasbourg receives funding from the Grand Est region and companies such as Crédit Mutuel Alliance Fédérale and Euro-Information, Heppner, Hager Group, Group ÉS, Socomec Group and 2CRSi. Thanks to the cutting-edge research in data science and artificial intelligence taking place at the Icube laboratory and to the strong relationships with socioeconomic stakeholders, the chair aims to train future data scientists and reinforce the new information technology and networks course at Telecom Physique Strasbourg while encouraging engineering students to take an interest in entrepreneurship and innovation.

APRIL 2023

The SIFER trade fair

Carnot TSN was present at the Salon International de l'Industrie Ferroviaire (SIFER) trade fair held at Lille Grand Palais. It was an opportunity to present a first-of-its-kind demonstrator illustrating the rebuilding of track cores using the XXL DED Additive Manufacturing process, a cutting-edge laser technology developed in partnership with Welding Alloys France, which ensures the maintenance and quality of rails.

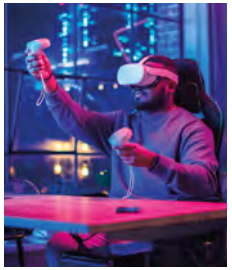
2023

FEBRUARY 2023

EURECOM at the World AI Cannes Festival

EURECOM was present at the second edition of the World AI Cannes Festival with its co-exhibitors Université Côte d'Azur, CNRS, Inria, Inserm, 3I Côte-d'Azur and Skema. The festival included many demonstrations from start-ups and public institutions as well as challenges and presentations from experts.

Mobile World Congress



EURECOM, part of Carnot Télécom & Société Numérique, took part in the WMC (World Mobile Congress) in Barcelona from February 27 to March 2, with BubbleRAN and OpenAirInterface Software Alliance. EURECOM's activities in fundamental and partnership-based research, training, open-source software development and standardization were presented to the public at this benchmark event.

MARCH 2023

The GLOBAL INDUSTRIE trade fair

Read the article

Carnot Télécom & Société Numérique is exhibiting at the Carnot Institutes Network stand at the Global Industrie trade fair. The aim is to foster collaboration between public research laboratories and companies and promote technological innovation and the transfer of knowledge.

IMT Atlantique honored by the LoRaWAN community

Read the article

Researchers at IMT Atlantique, Laurent Toutain, Ivan Martinez, Dominique Barthel, Rémi Demerlé and Hussein Al Haj Hassan received the LoRa Alliance Prestigious Award at the LoRaWAN LIVE ceremony in Orlando, USA, for their contributions to the IPv6 project as well as to the inter-Carnot BCB5G project. Their work on certifying the LoRaWAN radio communication protocol for IPv6 opens up new opportunities, particularly in the Internet of Things. The BCB5G project, funded by Carnot MINES and Carnot TSN, aims to strengthen the use of the SCHC protocol in industrial environments, promoting the integration of IoT and IT, and opening up prospects for 5G networks and beyond.

JUNE 2023

ICube celebrates its tenth anniversary

Read the article

The ICube laboratory is celebrating its tenth anniversary. Supported by Carnot Télécom & Société Numérique, this joint research unit of CNRS, the University of Strasbourg, INSA Strasbourg, ENGEES and INRIA, applies its skills in physics, engineering and computer science to areas such as the industry of the future, medical and surgical imaging and robotics, scientific computing, the environment and sustainable development, and artificial intelligence.

IMT at Le Bourget

Read the article

Institut Mines-Telecom (IMT), a Carnot Télécom & Société Numérique institute, was present with its partner company Esaris Industries at the Paris Air Show, which brings global players to Le Bourget to learn about the latest technological innovations. The framework agreement signed the previous year between the company and Carnot TSN commits the two partners to work together and innovate to meet the needs of the aerospace industry, particularly in terms of shortages of electronic components, materials and manpower.

MAY 2023

DSAIDS Chair: data science and AI for industry

Read the article

Supported by Carnot TSN, the DSAIDIS Chair (Data Science & Artificial Intelligence for Digitalized Industry & Services) is headed by two Telecom Paris professors and is working closely with Airbus Defence and Space, Engie, IDEMIA, Safran and Valeo to meet the challenges of industrial data exploitation. For the industry and services sector, massive data analysis and artificial intelligence (AI) represent opportunities to speed up decision-making, make reliable forecasts and boost efficiency.

FEMTO at Toyama

FEMTO Engineering specialists took part in the joint IFCS - EFTF conference held in Toyama, Japan. They presented the unprecedented frequency stability performance of the ULISS ultra-stable oscillator as well as the latest developments in the OSCILLATOR IMP time-frequency measurement platform.

JULY 2023

Launch of the "5G and Future Networks" PEPR

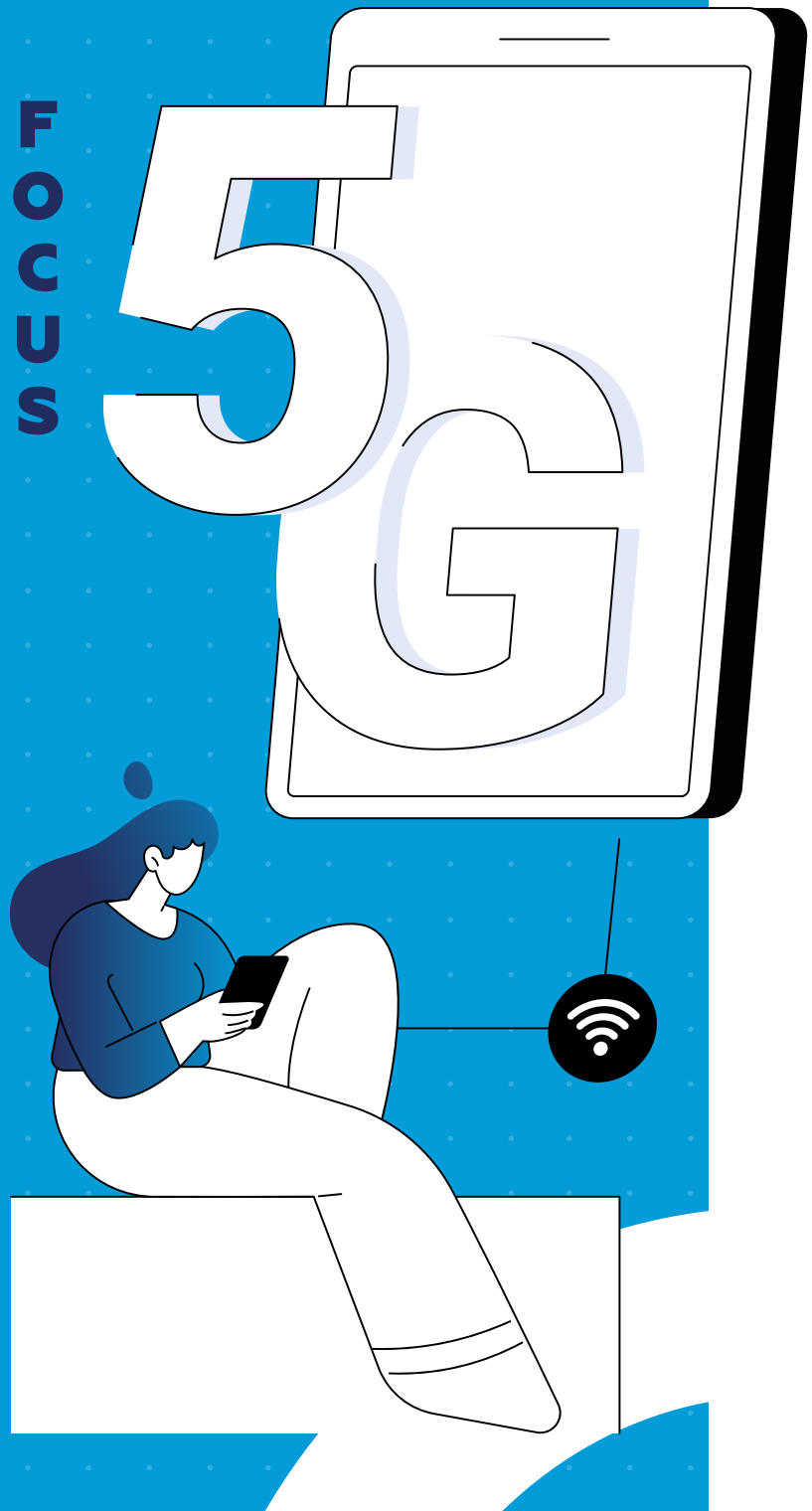
Carnot TSN will present the "5G and Future Networks" priority research program and equipment (PEPR), in which IMT will be responsible for setting up the France 6G platform.

A CIFRE thesis to fight urban pollution

Read the article

In partnership with Telecom Physique Strasbourg, a member of Carnot Télécom & Société Numérique, the ICube laboratory and Air&D, a company specializing in urban air quality, are working together on Xavier Jurado's CIFRE thesis. This thesis aims to design tools to use artificial intelligence to quickly identify air pollution in urban areas. A demonstrator was developed to predict air quality over a one square kilometer test area.

FOCUS



5G AND FUTURE COMMUNICATIONS NETWORKS

PREPARING THE DIGITAL SOCIETY OF THE FUTURE

Carnot Télécom & Société Numérique (TSN) works at the heart of the sovereignty and competitiveness issues linked to 5G and networks of the future. As a key player in higher education, research and innovation and in close collaboration with industrial, institutional, academic and socioeconomic stakeholders, the Institute leads many partnership-based research projects to develop innovative use cases for these technologies. It also brings its expertise to support public policy.

These two programs are closely interlinked, forming an unprecedented large-scale continuum between research, prematurity, maturity and industry that supports the intense drive for telecommunications sovereignty undertaken by public authorities in recent years.

Supporting public authorities

5G and subsequent technologies represent strong growth potential that France is counting on, based on real capabilities. The challenge is to incorporate innovations in hardware, software and system architecture to develop the value-added digital services of the future. Carnot TSN actively works with the French Ministry of the Economy, Finance and Industrial and Digital Sovereignty to define and implement the **National Acceleration Strategy for 5G & Future Networks,** an important component of the France Relance plan and the Future Investment Program.

- Contribute, in collaboration with the Centre National de la Recherche Scientifique (CNRS) and the Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA), to the 5G and Future Networks PEPR (Priority Research Program and Equipment), notably by leading "upstream" research that aims to support the development of 5G and 6G while assessing their impact on the environment.
- Institut Mines-Telecom (IMT) and its Carnot Télécom & Société Numérique (Carnot TSN) Institute are among the 17 winners of the "prematuration-maturation" call for proposals under the new France 2030 investment plan, with the FRAMExG program (French program of IP Massification for Europe in XG). This support will allow us to boost the transfer of solutions from public research to industry, notably through patents.

Training in the networks of the future

Institut Mines-Telecom's (IMT) IMTFor5G+ project has been selected as part of the "skills and professions of the future" call for expressions of interest in digital sovereignty. This initial and continuing education program unites seven IMT schools with companies (Alsatis, Clever Cloud, Ericsson, Infovista, NXP, Orange, Thales, WeAccess), trade associations (FFT, AIF, Cap Digital), associated partners (Broadpeak, Nokia, SNEF) as well as a club of supporters (CETIM, EDF, Numéum, Qualcomm, Red Technologies). It aims to roll out training courses nationwide for engineering and other students and professionals to develop mastery of the technologies, architectures and software involved in implementing and operating distributed systems, data-driven systems, AI and digital twins. The project is coordinated by Xavier Lagrange, a faculty member at IMT Atlantique.

Listen to our podcast,
"What does 5G still have in store?"

THE FUTURE NETWORKS PEPR

This program supports cutting-edge research and development in France throughout the entire value chain in 5G and future networks. Its multi-disciplinary and multi-sectoral approach goes beyond aspects related to telecommunications to support the upcoming digital revolution by incorporating environmental and societal impacts.

This program has four main objectives: expand 5G applications to boost the competitiveness of the French economy, develop sovereign French solutions, consolidate research and development resources for future generations of networks, strengthen training facilities and attract international talent.

The projects are grouped into four main areas: network architectures and services, end-to-end systems, technology components, platforms and demonstrators for the networks of the future.

BOOSTING THE NATIONAL TELECOMMUNICATIONS ECOSYSTEM

Thanks to the excellence of its researchers and engineers and their involvement in research transfer and commercialization, Carnot TSN acts as a key facilitator of the French networks and telecommunications sector and helps to create national champions.

Alongside these collaborative projects, which bring together large-scale academic and industrial consortia, Carnot TSN works directly with numerous French, European and international industrial partners through framework agreements, joint laboratories, CIFRE theses, readiness and incubation initiatives, and teaching and industrial chairs.

TSN is a major 5.x.G partner of companies such as Ericsson, Qualcomm, Nokia, Orange, Airbus and Thalès, as well as other major groups, SMEs and startups.

PARTNERSHIP-BASED RESEARCH PROJECTS

Carnot TSN is involved in many industrial research projects, including multi-annual collaborative projects subject to various waves of calls for proposals held by the French Ministry for the Economy and Finance and BPI France.

Beyond5G

This Carnot TSN-supported project funded by the government as part of the France Relance recovery plan and the Future Investment Program brings together IMT, EURECOM, Thales and Ericsson. It aims to make specific advances in terms of performance, resilience, quality of communication services (bandwidth, latency, network management) and solutions to guarantee reliability, network security and access for users and connected systems. The goal is to provide France with real, sovereign, capacity-building perspectives through a fruitful dialogue between research and platform testing. The project has already resulted in the publication of 15 scientific articles and the filing of several patents.

5GMetaverse

To meet the new needs brought about by the metaverse, this project, led by Airbus Group and with partners including IMT, Orange, Shift 89, Immersive Factory Kalray and Boa Concept, aims to evaluate and develop 5G technologies and standards, particularly for object and data identity management.

The pragmatic approach will rely on generic use cases derived from consumer and industrial applications. One of the aims is to bring the possibilities of the metaverse to Factory 4.0 tools such as digital twins and mixed reality.

Orange 5G PIEEC-MECT

IMT, EURECOM, Ekinops, CEA List and b<>com are working with Orange SA on this project that seeks to develop concrete solutions for the next decade by creating and deploying secure, sustainable digital infrastructures through "5G everywhere". The proposed solutions contribute to companies' digital transformation through vehicle-to-X infrastructures and private 5G networks. Collaboration with the microelectronics sector will help align research throughout the digital value chain.

FRAMExG

Led by Carnot TSN and Ouest Valorisation, this project brings together IMT, EURECOM, French technology transfer companies, b<>com and INRIA to create an academic "Team France" for 5xG. The aim is to bring breakthrough 5G-6G technologies to readiness and speed up their transfer to the socio-economic and industrial world. Involving the majority of the country's research laboratories, technology transfer offices and technological research institutes, the project is supported by major French and European manufacturers.

FRAMExG is based on a breakthrough approach to research commercialization and technology transfer: a patent factory system developed over many years by Carnot TSN efficiently generates a critical mass of patents, which can then be transferred directly to industry and/or brought before international standardization committees, where international competition and telecoms sovereignty - both crucial issues today - are at stake.

DEDICATED PLATFORMS

OpenAirInterface

This open-source software platform founded by EURECOM is dedicated to mobile telecommunications systems like 5G. By allowing for a complete reproduction of a 5G environment with all its key components, it provides a sandbox to design and test innovations in radio access networks. The platform also brings together a community of software developers called the OpenAirInterface Software Alliance, including academic and industrial partners that contribute to progress in scientific research into mobile networks.

Free5G

This project developed by Telecom Paris provides a remote-access sandbox for experiments, research and development. Experiments can be conducted into 5G radio access and the core network. Programmable embedded systems are also available for developing and testing protocol functionalities at the terminal/sensor level.

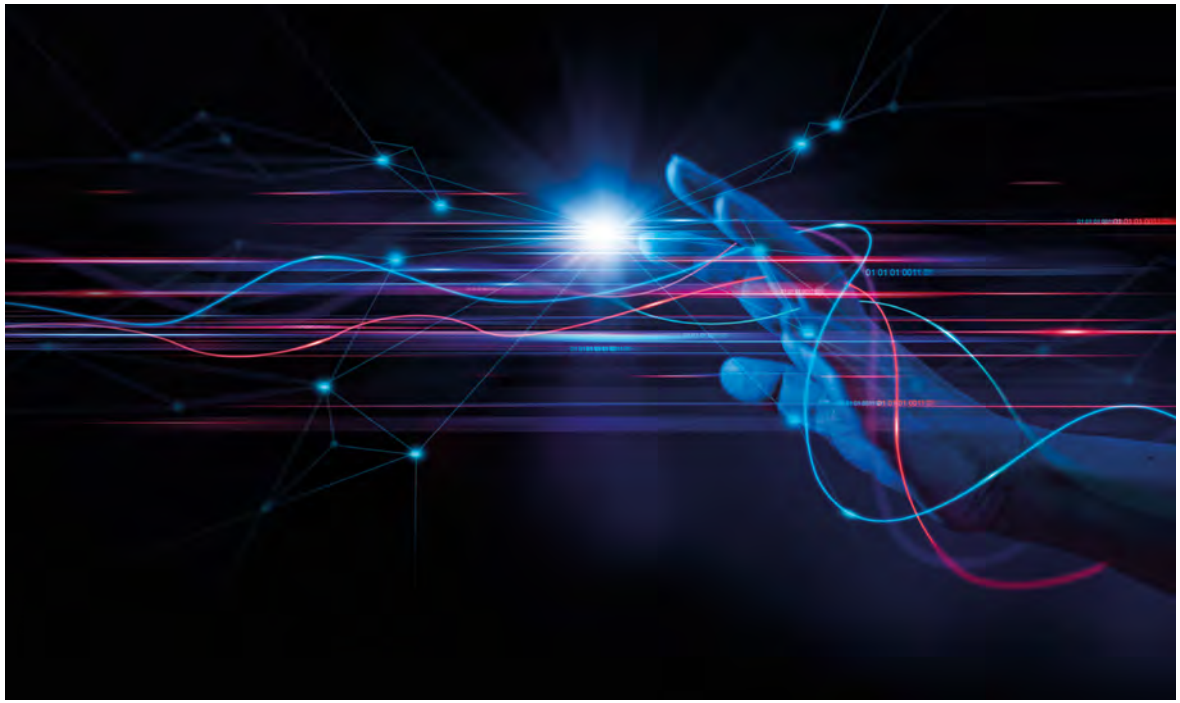
The platform includes two rooms. The first room is a confined environment that allows for experiments on operated bands. A complete 4G/5G network is available alongside a data center server infrastructure. A second room is used to make developments on ISM bands with an open, programmable sensor network.

EUROP

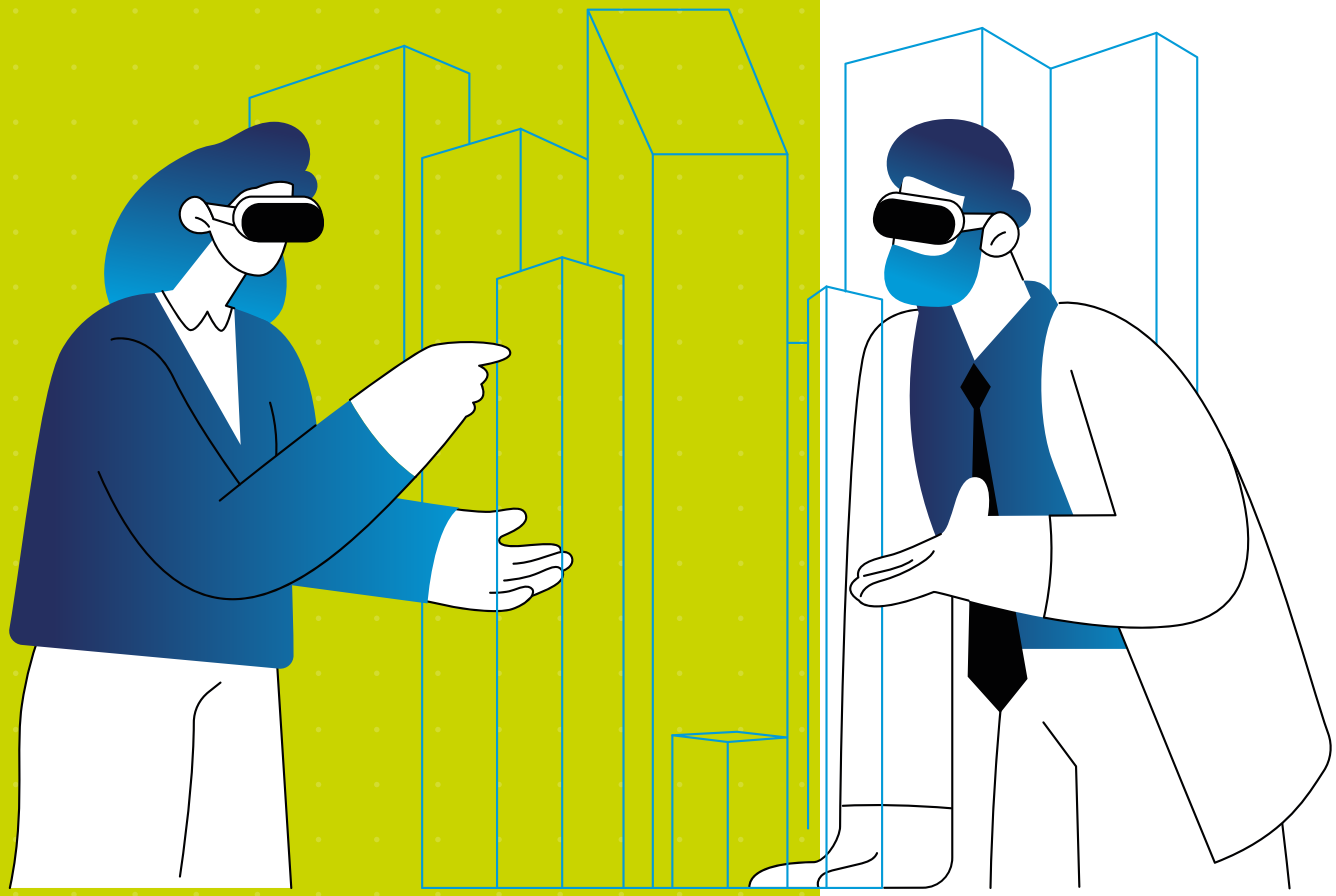
Located at Telecom Saint-Etienne, this platform recreates the entire network architecture (ADSL, fiber optics, etc.) and services (Internet access, telephone, TV) of a major telecom operator in a single room, linked to a mobile network.

EUROP is both a tool for partner companies and a tool to train students. The platform allows users to try out materials, equipment and services by simulating the data pathway from a low-bandwidth end client (such as an individual in the countryside) to a fast, professional connection (such as a corporate fiber optic network in a city center).

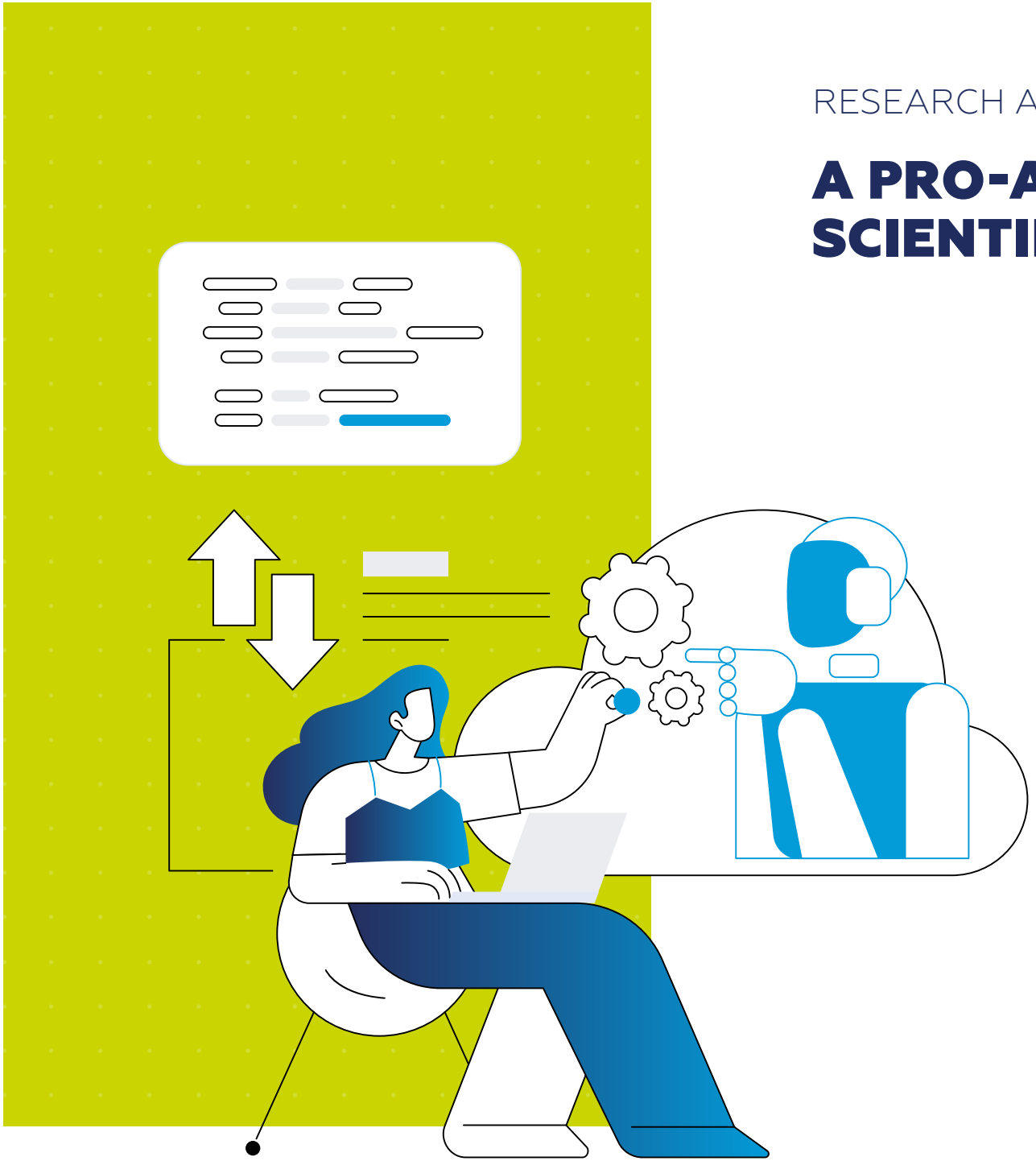
*In addition to these three **"mobile network core" platforms,** Carnot TSN offers its socioeconomic partners many complementary, experimental and digital platforms in cybersecurity, artificial intelligence, IoT, edge computing, simulation, networks and applications.*



SPEED UP THE INDUSTRY OF THE FUTURE THROUGH RESEARCH AND INNOVATION



The Carnot Institutes' mission is to develop partnership-based research and reach out to companies.
Carnot Télécom et Société Numérique leverages its scientific expertise and know-how to develop breakthrough digital solutions in a collaborative approach to transfer technology to industry.
Its innovations contribute to the development and competitiveness of its industrial partners and offer answers to major scientific, economic and social challenges, including the industry of the future, smart devices and networks, cybersecurity, big data and artificial intelligence, smart cities and digital health.



RESEARCH AND INNOVATION

A PRO-ACTIVE SCIENTIFIC POLICY

Maintaining the establishment's scientific excellence as recognized by the Carnot label requires research on upstream subjects that could lead to scientific or technological breakthroughs in the distant future, but that always show potential for economically viable applications.

This goes hand in hand with anticipating industrial and market demands and changing standards. The recipe of patents, startups and research partnerships pays off at Carnot TSN.

Find out more about FLORIA

FLORIA: detecting floods in cities using satellite imagery and AI

The ICube laboratory launched the FLORIA project with support from Carnot TSN to automate the detection of city floods by using deep learning techniques to analyze satellite images. The goal is to use ICube's SERTIT platform to provide dynamic maps and create alerts to improve the emergency response to city floods.

The project uses radar satellite images from the Sentinel-1 mission of the European Space Agency's Copernicus program, available for free, day and night, even in cloudy conditions. Analyzing data from urban areas is complex given how many times radar waves bounce off buildings and roads. Multiple images must be compared to identify changes to the radar signal that indicate the presence of water on the ground: an increase in the amplitude combined with a lower coherence of the images.

Once automatically extracted from three satellite images, two before the event and one after, the data is analyzed using an artificial intelligence to predict the probability of a flood. The model required continuous training using data built from manually created maps of past floods. Future improvements include regularly training the model and using a high-performance computing platform to further reduce processing time.

Yōkobo: a robot to create bonds at home?

Thesis defended on January 24 at Strate

When couples retire, they spend more time together, which can reveal disagreements that were previously hidden by professional obligations. Can robotics help overcome them? This question was explored in a PhD thesis supported by Carnot TSN that brought together Orange, Strate School of Design, the Laboratoire des Sciences du Numérique de Nantes (LS2N) and the Tokyo University of Agriculture and Technology in Japan. The work led to Yōkobo, a behavioral robot to improve retired couples' quality of life. Researchers explored the expectations of potential users who wanted a household object that could carry out tasks while acting as a voice assistant. The study uncovered certain cultural specificities: in Japan, users wanted to overcome the feelings of loneliness they felt despite the presence of their spouse.

Yōkobo acts as a sort of "smart tidy" and discreetly simulates the presence of a third party. It responds to environmental stimuli, for example by discussing the weather when someone approaches or imitating their movements. It can remember previous interactions with users, whom it recognizes through their keys. Although the quality of Yōkobo's design and interactions were widely acknowledged, the researchers stress that robotics is not the universal solution for improving well-being and communication within the home. The technology must be implemented in a thoughtful, targeted way and demonstrate its real added value.

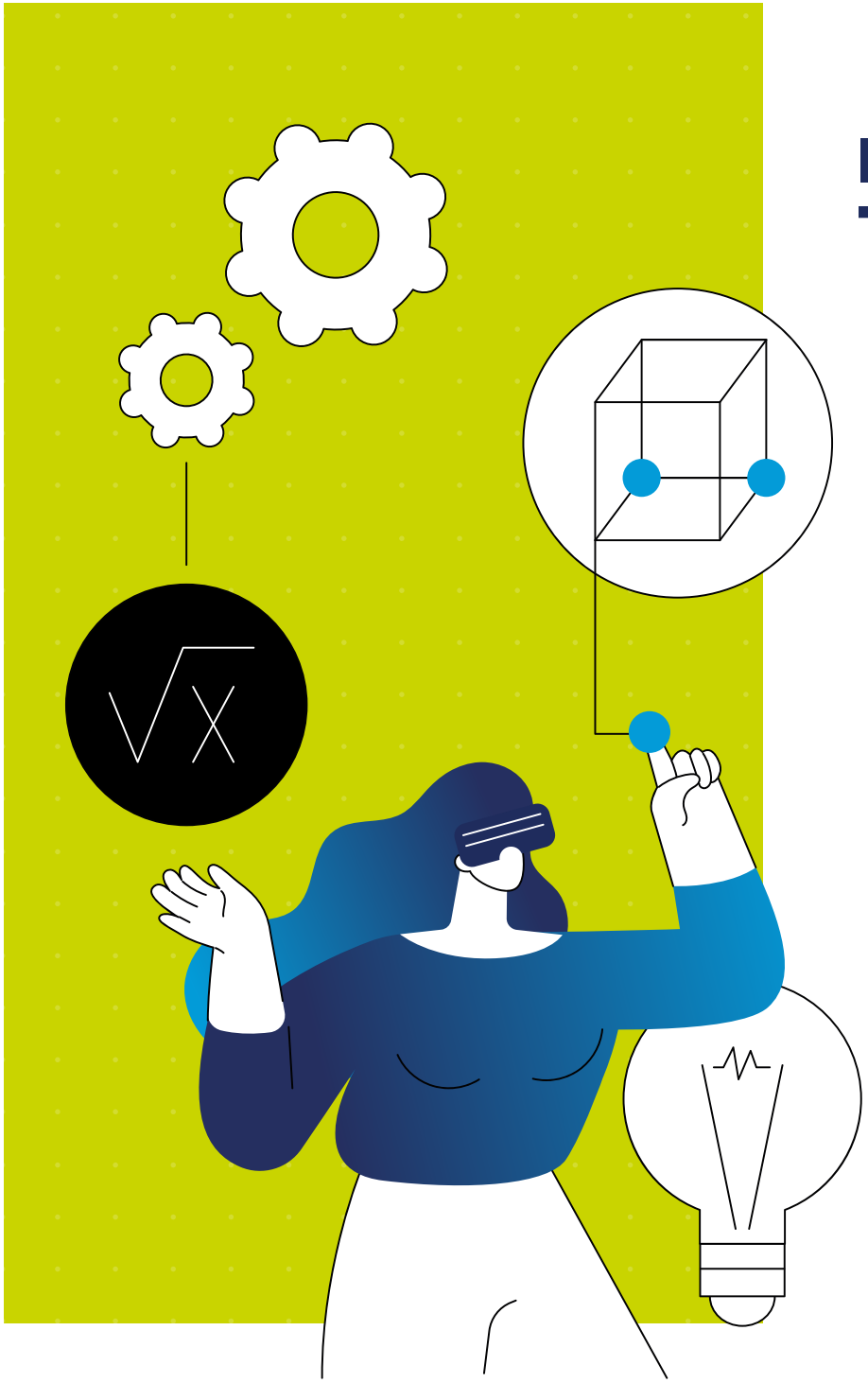
Find out more about Yōkobo

Find out more about cryptocurrency

Cryptocurrency: Unblock the chains

Cryptocurrencies like Bitcoin rely on blockchain technology, where data is decentralized over a peer-to-peer network. "*Trust in flawed financial institutions is being replaced by trust in technology,*" says Petr Kuznetsoc, researcher at Telecom Paris. However, one of the drawbacks of these systems is that they use energy-hungry algorithms to secure transactions and guarantee their integrity. Cryptocurrencies' reliability depends on their resilience to errors and attacks. One challenge consists in ensuring that transactions are validated at the right time, so that all Internet users have simultaneous access to the same version of the blockchain and to prevent fraud. Consensus protocols between participants guarantee this synchronicity, but these are generally cumbersome and complex.

The TrustShare: Blockchain-oriented Innovation Chair consortium, led by Telecom Paris and financed by Mazars Conseil and Caisse des Dépôts et Consignations, aims to streamline these operations while maintaining a high level of security. The goal is to take into account the level of trust between participants in the same localized space, which is greater than over the blockchain as a whole: streamlined but equally secure validations can be considered for transactions carried out within this space. Another approach is to check only a partial order in the blockchain instead of the absolute order, which not all transactions necessarily require. Decentralized financial systems could benefit from this promising work in the future.



INNOVATION AND TRANSFORMATION PROJECTS

Since 2006, Carnot Télécom & Société Numérique has been committed to promoting business innovation and supporting the economy. Our research teams are highly attentive to the needs of the industrial world, responding with agility and creativity to the scientific and technological challenges that face our society and contributing to the emergence of tomorrow's operational solutions.

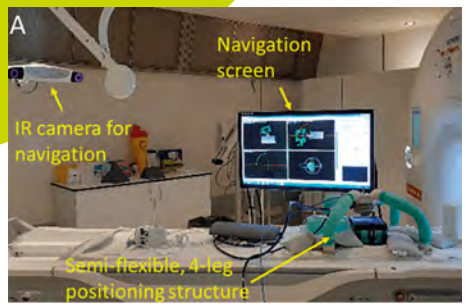
Here's a look at some of the innovation and transformation projects that made a difference in 2021.

Initiated in 2022, Carnot TSN's partnership with Esaris Industries via the IMT schools saw intense development in 2023. This medium-sized industrial company supplies electromechanical components and sub-assemblies to demanding, hyper-competitive sectors such as aeronautics, aerospace, railways, electrical equipment, and healthcare. This partnership involving a three-way approach between R&D, innovation and training was created to support the company's development and the strategic diversification of its activities. It targets the major industrial, energy, digital, environmental, human and managerial transformations linked to the industry of the future.

In addition to the research and engineering projects currently underway, this ambitious partnership places a strong emphasis on the training and integration of young engineers into the world of industry, particularly aeronautics, which is currently struggling to attract and recruit suitable profiles.

A partnership of this kind between academia and industry is an excellent way of addressing this problem and helping to remedy it in the long term. In June 2023, the two partners attended the Paris Air Show with a joint stand and a common visual identity aimed at the many students visiting Le Bourget, as well as manufacturers and industry groups. It sought to showcase and spread this positive relationship between industry and academia. This joint initiative, which attracted a great deal of attention at Le Bourget, encouraged over a hundred students and alumni to re-engage with careers in industry. Many manufacturers have expressed their interest in similar projects, and larger-scale initiatives could be launched at industry level.

This partnership illustrates one of Carnot TSN's main strengths: its ability to work with industrial partners to combine research and training, in line not only with their innovation strategy but their HR strategy and needs as well.



UFOGUIDE: Burning bone tumors with focused ultrasound

By increasing the frequency and duration of remissions in cancer patients, medical advances are leading to more bone tumors due to metastasis. Focused ultrasound treatment could be used to reinforce radiotherapy, which is limited by the use of ionizing radiation. The challenge is to make these operations easier, less costly and therefore more accessible. This is the aim of a collaboration between the ICube laboratory, represented by Jonathan Vappou, and the company Image Guided Therapy, headed by Erik Dumont, with the help of Axilum Robotics and the support of Carnot TSN.

One of the challenges is the use of MRI, which is essential for checking that the beam and temperature are correctly applied but which precludes the presence of any metallic elements. The team's innovative approach consisted in devising a system made up of flexible legs to precisely position the transducer emitting the ultrasound waves towards the area to be treated. Called UFOGUIDE, this device was successfully tested on a patient suffering from bone metastasis. The procedure eliminated over 80% of the tumor, considerably reducing the patient's pain. The collaboration between researcher Jonathan Vappou and the company Image Guided Therapy continues, aiming to improve the UFOGUIDE device and explore new therapeutic approaches, such as the use of focused ultrasound for targeted drug delivery. This promising research could open up new perspectives in the treatment of bone tumors and other conditions.

Find out more about UFOGUIDE

Poladerme: the device that lights up the skin

Researchers at the ICube laboratory (Université de Strasbourg, CNRS, INSA Strasbourg, ENGEES), with the support of Conectus Alsace, have designed Dermapol, an innovative dermatological diagnostic device based on spectropolarimetry and machine learning. Currently, skin diagnoses rely mainly on visual examinations made with dermatoscopes, but these methods stop at the skin's surface. Dermapol overcomes this limit by scanning the various layers of the skin with lights of various wavelengths and then examining the interaction between the light and tissues with image analysis and processing techniques.

Created in partnership with Medical Devices Venture, a subsidiary of ARCHOS, Poladerme aims to exploit the potential of this technology in dermatology and cosmetology. Its roadmap includes the creation of a database associating spectropolarimetric images with biopsies. This data will be used to train artificial intelligence algorithms designed to provide the medical profession with an innovative tool to help diagnose skin disorders.

TECHNOLOGY PLATFORMS

HELPING COMPANIES INNOVATE

Carnot TSN brings together nearly 80 R&D technology platforms throughout the country. These are at the core of our components and situated as close as possible to researchers and regional scientific centers of excellence (nanotechnologies, healthcare, environmental imagery, etc.).

Platforms, the entry point for companies

Carnot TSN offers a wide range of experimental and digital platforms combining a high level of expertise with state-of-the-art equipment in the target fields of application. They are open to public and private partners to develop their activities in research, development, transfer of results (proofs of concept, prototyping, trials, etc.) as well as training.

Platforms of excellence

13 platforms have been singled out by the "Carnot TSN Platform" label of excellence, guaranteeing a formalized service offering open to businesses.

Five of these(*) have also been awarded the "2023 IMT Platform" certification and the support of Institut Mines-Telecom's self-named strategic program to boost their service offering across the entire technology readiness scale (TRL).

13 certified platforms

NETWORKS AND SMART DEVICES

OpenAirInterface, EURECOM
Open source hardware/software for wireless communications

EUROP, Telecom Saint-Étienne
Fixed network and industrial transfer of ultra-high-speed communication technologies

RAMSES*, Telecom Paris
Analysis and production code of embedded real-time systems

TTool*, Telecom Paris
Simulations and experiments in network configuration

Free5G*, Telecom Paris
Design, development and evaluation of new network features in a software radio environment

DATA AND SERVICES

TeraLab, IMT
Big data and cloud computing

OMNI, IMT Atlantique
Transferring the social sciences and humanities to the digital society

HEALTHCARE AND AUTONOMY

SHELL
Network of living labs in healthcare, autonomy and quality of life

SECURITY

Cybersecurity*, Telecom SudParis
Designing, evaluating and demonstrating security and defense mechanisms

SMART MATERIALS

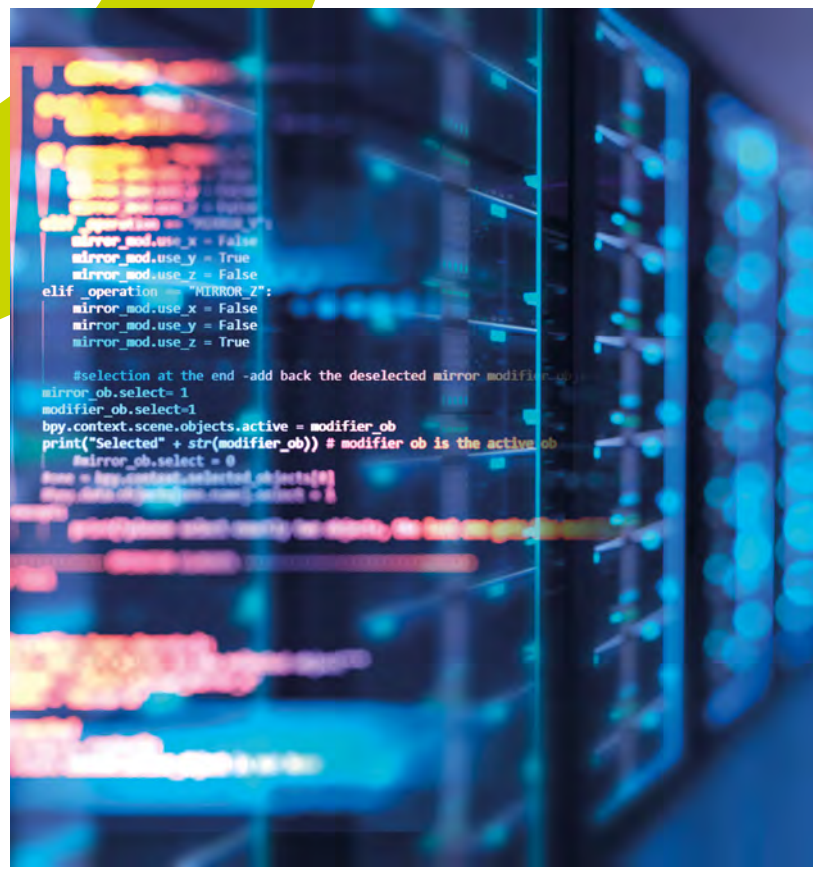
Arago*, IMT Atlantique
Optical technologies and smart materials for the industry of the future

MIMENTO, FEMTO Engineering
Micro- and nanotechnologies for mechanical, acoustic and optical microsystems

ENVIRONMENT

ICube-SERTIT, Telecom Physique Strasbourg
Regional remote detection and image processing service

TASM, IMT Atlantique
Digital communication via submarine acoustic link



GAIA

Artificial intelligence brings data to the heart of the innovation process. ICube lab's GAIA (Graphical Computing, Data Analysis and Artificial Intelligence) platform helps companies to explore and make the most of their data in all their AI-related projects. Funded by Carnot Télécom & Société Numérique, it combines expertise in computer science, scientific computing and artificial intelligence to offer a comprehensive range of services covering all aspects of data science, including digitization, data management, processing and analysis, modeling and simulation, visualization and interaction. In conjunction with academic and socio-economic partners, the platform provides expertise and support for research and/or commercialization projects.

Find out more about the Inetlab platform

Inetlab platform: a full-scale laboratory for connected objects

Evaluating the energy performance and consumption of IoT (Internet of Things) applications and protocols is a complex process that could be made easier by an experimental infrastructure. The SILECS initiative responds to these challenges by creating the IoT-LAB platform with more than 1,000 connected objects rolled out over various sites in France. Operated by the Inetlab team at the ICube laboratory in Strasbourg, this infrastructure is open to all, allowing everyone to evaluate communication protocols by analyzing parameters such as radio power and transmission speed. It also measures equipment's energy consumption, a crucial factor since these are often powered by battery. IoT-LAB also facilitates academic research and large-scale experimentation in the field of the Internet of Things and encourages multi-disciplinary collaborations like NASA's Harvest project, which called on the Inetlab team to roll out a network of long-range weather stations in Uganda.

The platform's goal is not just to incorporate networks and connected equipment but data centers as well in order to evaluate the energy performance and consumption of each link in the chain. It also studies the effect of centralized and decentralized data processes and the impact of the influx of IoT data on Internet networks. Carnot TSN's support boosted this initiative's visibility and encouraged collaboration between academia and industry.

THE CARNOT NETWORK

THE MOST POWERFUL RESEARCH OFFERING FOR COMPANIES' INNOVATION

Carnot Institutes are public research structures certified by the French Ministry for Research, committed to developing and carrying out partnership-based research initiatives in support of innovation at socioeconomic stakeholders and companies of all sizes, from small business to large corporations. They form a unique network of 39 French public research establishments renowned for their ability to meet the R&D needs of companies of all sizes. They are the largest public research force capable of tackling all fronts of R&D to support France's economic recovery and sovereignty through innovation.

For 16 years, the Carnot Institutes have become key players in uniting public and private actors and in completing scientific and technological transfers to boost companies' innovation. Their remarkable results and their unfailing commitment to our industrial companies place them on the front lines of the industrial revival.

Jean-Denis Muller
President of AiCarnot

La recherche CARNOT pour l'innovation des entreprises

The Carnot label

The Carnot label was created in 2006 and is designed to expand partnership-based research. This means managing research work by public laboratories in partnership with socio-economic players – mainly companies (from SMEs to large groups) – in response to their needs.

A strong response to the challenges of industry

With 20% of France's public research staff, the Carnot Institutes carry out 55% of the R&D outsourced by companies to public research laboratories. Each year, more than 10,000 direct R&D contracts are signed between the institutes and companies in all industrial sectors.

Learn more about the Carnot network

key figures for 2022

39 Carnot Institutes located in all regions of France

20% of public research staff

55% of R&D funded by companies at public research institutes is entrusted to the Carnot network, totaling **more than 11,000 research contracts** per year, **40% of which is with small and medium businesses**

€600 m in contractual research with companies

Other corporate income

- **€48 m** in IP
- **€143 m** in **European** collaborative projects
- **€216 m** in **national** collaborative projects
- **€148 m** in services and consulting

100 companies spun off during the year

35,000 full-time equivalent research professionals, including 10,000 PhD students (1,600 in CIFRE contracts)

28,500 A-rank publications per year

1,150 **priority** patents filed during the year, making the Carnot network the **1st in French filers**

An active joint-laboratory creation policy with companies (more than 45 in 2021)

2022 figures

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