# PUSHING THE FRONTIERS OF TECHNOLOGY

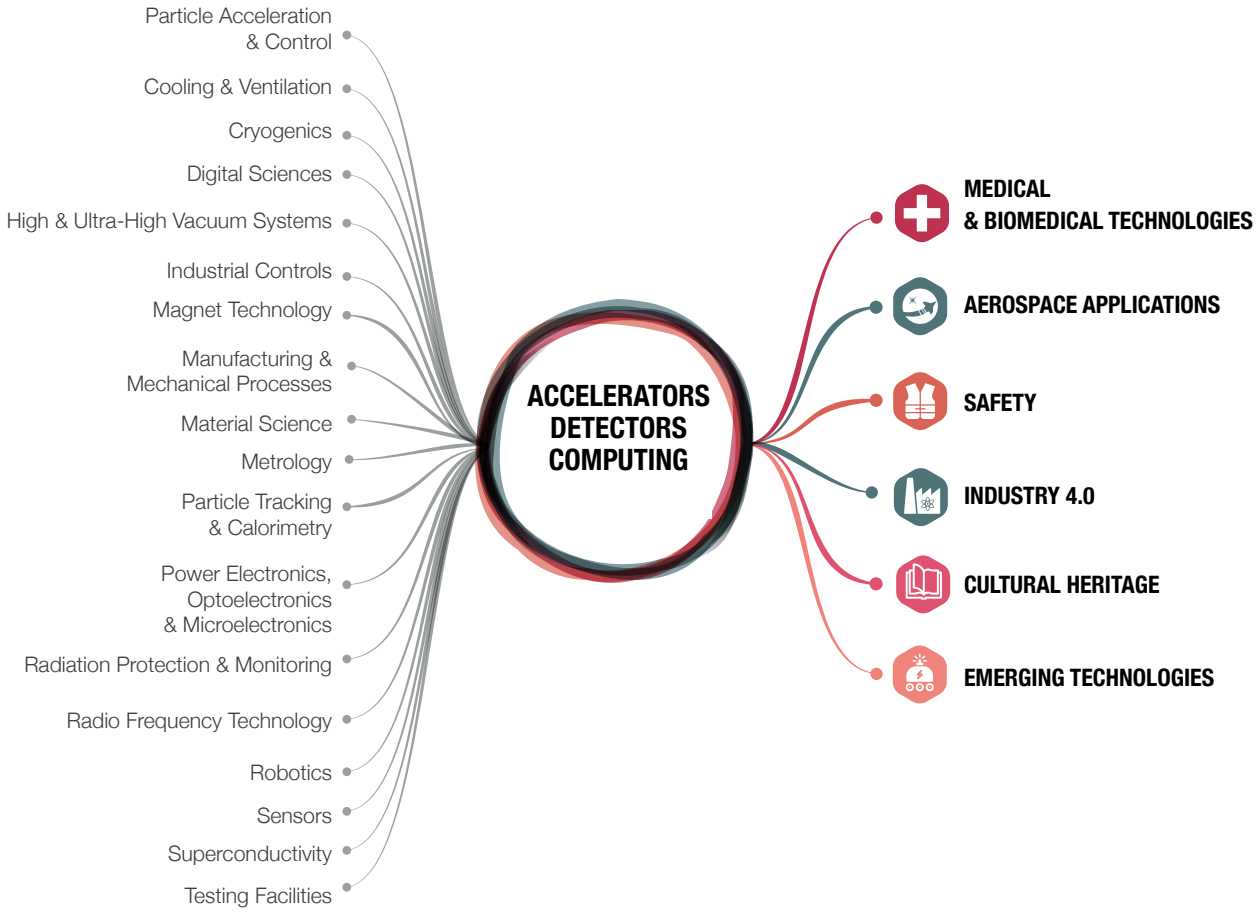
***An important part of CERN's mission is to ensure that its pioneering technology and know-how have an impact beyond the walls of the Laboratory. This transfer of knowledge is beneficial not only to the industry in CERN's Member States but also to society as a whole.***

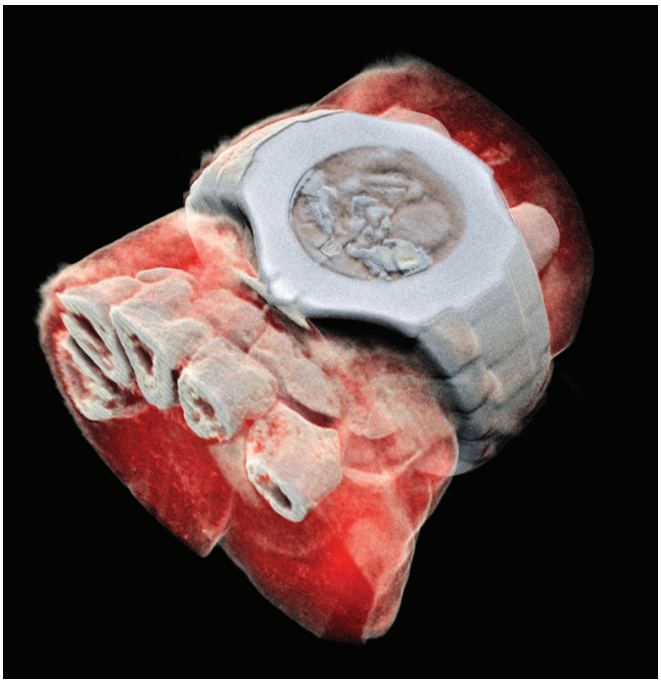
The year 2018 saw many examples of successful knowledge transfer in fields ranging from medical and biomedical technologies to aerospace applications and beyond. CERN attended the SLUSH entrepreneurship conference in Helsinki, where the 2018 State of European Tech report was presented. For the first time, CERN was a data-partner in the report and featured as an example of how fundamental research institutes act as drivers for innovation through their contribution to technological and human capital.

The introduction of Knowledge Transfer (KT) "Discovery Days" at CERN increased collaborations with multinational companies by inviting them to come to the Laboratory to explore potential solutions to industrial challenges.

*Diverse Fields of Application*

*The technologies designed for the Large Hadron Collider and used in the discovery of the Higgs boson have led to major developments related to accelerators, detectors and computing that are relevant to society.*





*CERN technology was the basis for the first 3D colour X-ray scan of a human. The colours visible on this image of a wrist represent different energy levels of the X-ray photons as recorded by the detector, identifying components such as fat, water, calcium and disease markers.*

## MEDICAL AND BIOMEDICAL TECHNOLOGIES

CERN's long-standing contribution to medical and biomedical technologies continues to be fruitful.

MARS Bioimaging Ltd (a spin-off from the Medipix Collaborations and the University of Canterbury, New Zealand) produced the first images of a human body using their breakthrough 3D colour scanner, based on the Medipix3 technology. Medipix is a family of imaging and detection chips developed at CERN.

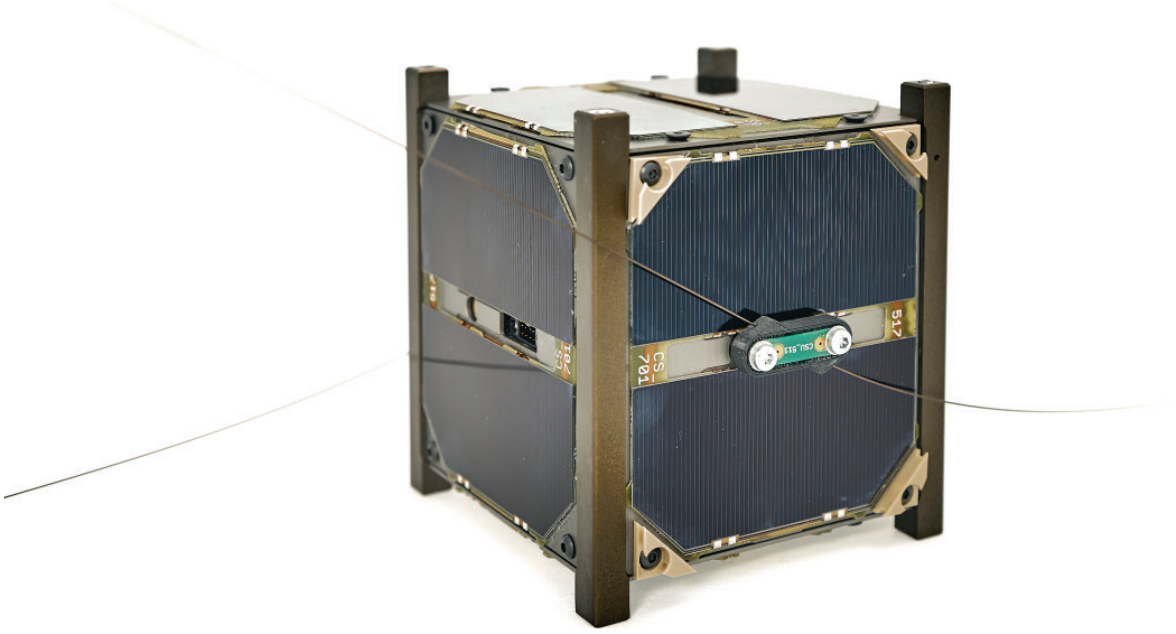
An innovative design for hadron-therapy gantries, GaToroid, was conceived in 2018 using CERN's expertise in superconducting magnets. Gantries steer the therapeutic beam around the patient so that a tumour can be treated from various angles. GaToroid promises to revolutionise the field by introducing a toroidal magnet that bends the treatment beam without needing to rotate the structure, thus substantially reducing the weight and cost compared to fully rotating gantries.

The first CERN medical-technology hackathon was organised to address challenges set by healthcare and industry partners using relevant CERN technologies. The winning teams' proposals aimed to improve access to vital healthcare in rural areas (using C2MON technology) and to screen radiopharmaceuticals more efficiently (using the GEMpix detector). Both teams won a stay at CERN to continue to develop their projects.

## AEROSPACE TECHNOLOGIES

CERN continues to contribute to the aerospace community through partnerships and by providing access to its unique competences and facilities. CHARM, a facility at CERN to test electronics in complex radiation environments, tested its first full spacecraft, CELESTA (CERN Latchup and Radmon Experiment Student Satellite). The satellite was tested under a range of conditions that it can expect to encounter in space and proved its reliability. The payload, based on CERN radiation-monitoring technology, confirmed its very high sensitivity even to low fluxes and delivered outstanding performances overall.

Experts from ESA and IROC Technologies came to CERN to perform tests at VESPER (Very Energetic Electron Facility for Space Planetary Exploration Missions in Harsh Radiative Environments), which is part of CLEAR (CERN Linear Electron Accelerator for Research). VESPER was used to evaluate the effects of high-energy electrons on state-of-the art electronics that are being considered for the JUICE (Jupiter Icy Moons Explorer) mission. The outcome will help the JUICE project to optimise spacecraft.



*The first full satellite was tested in CERN's CHARM facility in July. CELESTA will use CERN radiation-monitoring technology in space.* (CERN-PHOTO-201807-181-2)

## A WIDE VARIETY OF APPLICATIONS

CERN's unique environment combining ultra-high magnetic fields, high voltages, radiation and extremely low temperatures requires innovative safety solutions to detect and prevent threats. The goal of the start-up SAFETYN is to improve safety for general aviation by developing a novel device that acts as a pilot's guardian angel, collecting data and assisting in improving situational awareness by using the open-source ROOT/TMVA framework and machine-learning libraries. In 2018, SAFETYN SaS joined Innogex, the French incubator of CERN technologies.

The construction and operation of the accelerators, detectors and computing facilities results in expertise in industry 4.0. A2O Innovation Solutions, a start-up providing technologies for the reduction of weight and $CO_2$ emissions and for improving operational efficiency has been accepted by the UK BIC of CERN technologies. A2O plans to integrate the CERN technology Multi Memory System (MMS), originally developed for LHC Beam Position Monitors, into its CHASM system.

The MACHINA collaboration between CERN and INFN aims to construct a 'miniaturised' particle accelerator for use in cultural heritage. The MACHINA device will reduce the cost of using the PIXE elemental analysis technique, which is used around the world to study artworks. In April 2018, the project was launched at the *Opificio Delle Pietre Dure* (OPD) workshop in Florence, one of the world's leading institutes in art restoration.

## ACCELERATING INNOVATION

The KT group supports the innovation process at CERN through its activities, collaborations and services. It provides advice, training and networks to facilitate the transfer of the Organization's technology and know-how. In 2018, CERN's scientists and engineers brought 77 new technologies to the group's attention, including software, electronics, and detector and accelerator components.

The CERN Knowledge Transfer Fund can help bridge the gap between research and industry. Established in 2011, and supported through revenue from the KT group's commercial agreements, 44 projects have been funded to date through a competitive process.

In 2018, three projects were selected: a diamond-based universal multimode-to-single-mode laser converter, a method for thin-film coating of complex shapes and an open-source research data management platform. In addition, the CERN Medical Applications Budget funded a new project on radioisotope production, as well as the work of four new researchers.

## FRUITFUL COLLABORATIONS

CERN cultivates interactions between researchers, businesses and policy makers in its Member States, in order to facilitate the fruitful transfer of knowledge to industry. In particular, CERN participates in projects co-financed by the European Commission (EC). It is currently involved in six projects with a strong knowledge-transfer component (AIDA-2020, QUACO, AMICI, ARIES, FuSuMaTech, and ATTRACT), corresponding to approximately 34.5 million euros in EC co-funding.

Half of that amount comes from ATTRACT, a pioneering initiative that aims to fund 170 breakthrough concepts on detection and imaging technologies. The project represents a significant opportunity for CERN and its associated research and innovation communities to consolidate technology concepts and establish new knowledge-transfer links. ATTRACT's first call, in August 2018, received a total of 1211 proposals on topics such as sensors, front- and back-end electronics, data-acquisition systems and computing, and software and integration.

## FOSTERING ENTREPRENEURSHIP

There are now 28 start-up and spin-off companies based on CERN know-how and technologies, specialising in diverse domains.

In 2018, the CERN Enlarged Directorate endorsed a new spin-off policy, which details the support given by CERN to spin-offs and clarifies the relationship with these companies.

The first CERN Entrepreneurship Student Programme (CESP) took place in late summer. CESP, a project under the umbrella of the CERN and Society Foundation and fully funded by the company Strangeworks, invited ten students from around the world to visit CERN. Over five weeks, they were coached by CERN KT experts with the aim of identifying and evaluating exploitable technologies and developing concepts for new ventures.

CERN signed its tenth Business Incubation Centre (BIC) agreement with PARK INNOVAARE in Switzerland, a centre run in collaboration with the Paul Scherrer Institute (PSI) and the University of Applied Sciences and Arts in Northwestern Switzerland (FHNW).

## DOING BUSINESS WITH CERN

To construct and operate its particle accelerators, detectors and computing facilities, CERN places orders and contracts for a wide range of equipment and services every year. More than 40% of the Organization's annual budget is returned to industry through procurement activities, where contracts with CERN help industry to drive its innovation.

In 2018, CERN's procurement activities included 175 price enquires, 80 invitations to tender and 65 600 orders of various types. The Procurement Service also continued its extensive activities for the High-Luminosity LHC (HL-LHC). Major HL-LHC contracts were awarded, ranging from civil-engineering construction work and superconducting radiofrequency cavities to $CO_2$ pumps for the ATLAS and CMS detectors. In addition, contracts were placed for the architectural and engineering consultancy services for the new Science Gateway (see page 35), and IT contracts with Microsoft and Oracle were renegotiated. To streamline the purchasing processes at CERN, a new online procurement platform for the Organization's suppliers was launched and more than 2000 firms have already registered.

In order to create links between CERN and national industries, the Procurement Service regularly participates in a variety of conferences and events. Eight Member States organised industrial exhibitions and visits at CERN in 2018, while the Procurement Service also took part in industry events held in eight different Member and Associate Member States. One of these, the first Big Science Business Forum (BSBF), took place in Copenhagen, Denmark, gathering 18 advanced big-science organisations to meet European companies. In addition to giving presentations, CERN ran a large stand presenting ongoing and future procurement opportunities.

*CERN Director for Accelerators and Technology, Frédérick Bordry, highlighted procurement opportunities for the High-Luminosity LHC upgrade project at the Big Science Business Forum.*