PUSHING THE FRONTIERS OF TECHNOLOGY

CERN inspires visionary thinking. Since its beginning, it has acted as a trailblazer in technologies relating to accelerators, detectors and computing. As a laboratory with a long-term research plan, it is continuously innovating, creating solutions that concretely benefit both its Member State industries and society as a whole. The year 2017 marked twenty years since CERN set up a reinforced structure to support its knowledge and technology transfer activities. Today, these activities are stronger than ever.

The first isotope produced by CERN-MEDICIS (Medical Isotopes Collected from ISOLDE). This new facility has begun to provide a range of innovative medical isotopes for hospitals and research centres across Europe. (CERN-PHOTO-201803-081-2)

DIVERSE APPLICATION FIELDS

The technological and scientific advances behind high-energy physics have historically contributed to the field of **medical and biomedical technologies**, particularly those relating to areas within therapy, diagnostics and imaging, as well as big data and medical computing. In 2017, that contribution was significantly strengthened by the Council's approval of CERN's new medical applications strategy.

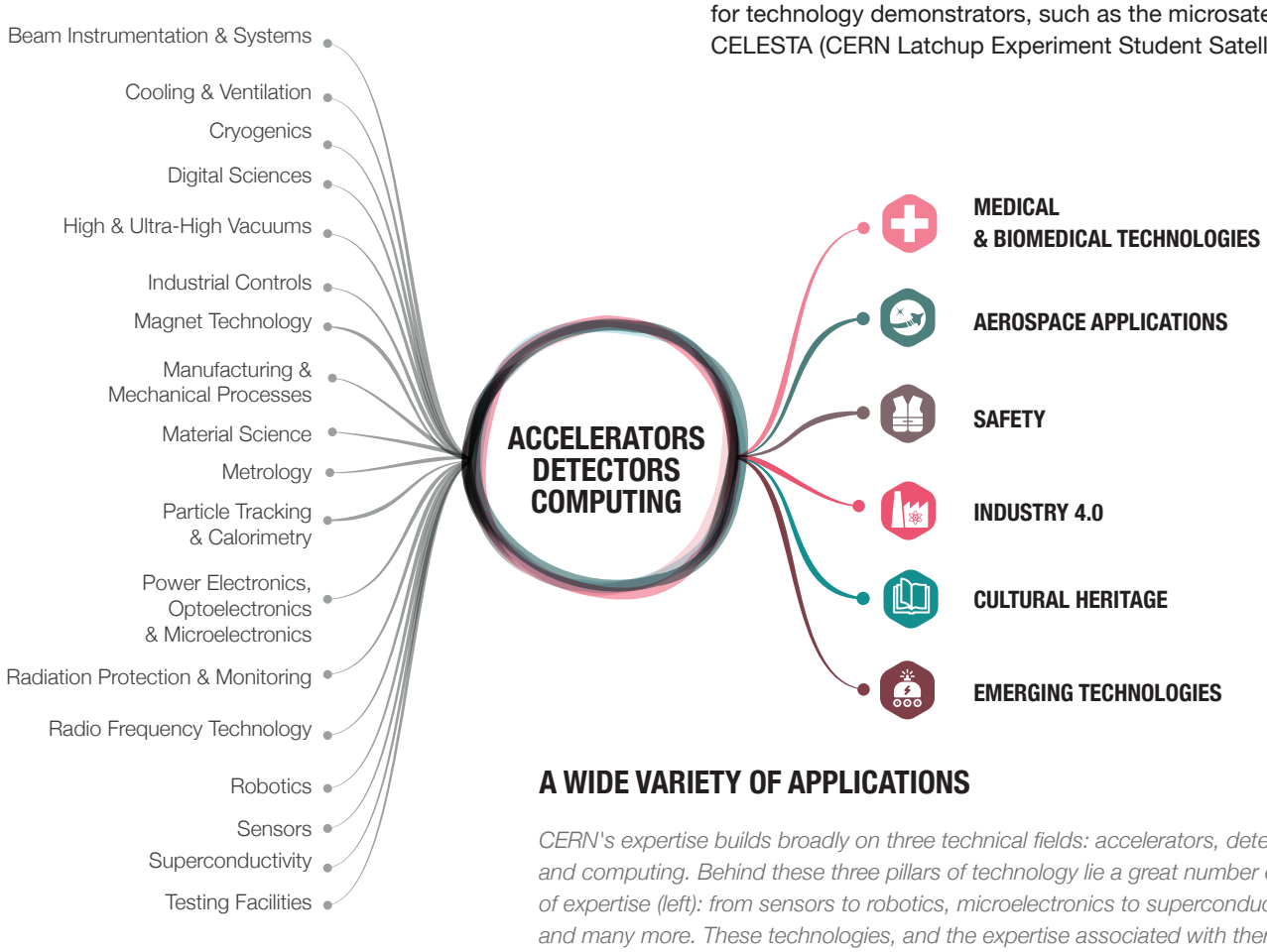
In September 2017, CERN-MEDICIS (Medical Isotopes Collected from ISOLDE) entered the commissioning phase, before producing its first isotopes in December. This unique facility is designed to produce unconventional radioisotopes with the right properties to enhance the precision of both patient imaging and treatment. It will expand the range of radioisotopes available for medical research – some of which can be produced only at CERN – and send them to hospitals and research centres in Switzerland and across Europe for further study.

International experts in accelerator design, medical physics and oncology met at CERN in October, following on from the first CERN-ICEC-STFC workshop in 2016. The ambitious plan is to design an affordable, easy-to-use and robust medical accelerator for challenging environments.

The programme aims to have facilities and trained staff available to treat patients in low- and middle-income countries by 2027.

Another medtech development involved sharing CERN's expertise in digital sciences, a field with strategic applications in industry. CERN experts trained Sanofi Pasteur, the vaccines business unit of the global life sciences company Sanofi, to apply novel machine-learning techniques to various production challenges. Continued collaboration will test and explore tools to try to improve vaccine production, helping more people to access vital vaccines.

Aerospace is a major application area for CERN's technologies and expertise. In April, the French space agency, CNES (Centre National d'Études Spatiales), and CERN signed an important framework cooperation agreement. With the support of the CERN Knowledge Transfer Fund, three projects formalised by the agreement have already begun: radiation tests of the Eyesat nanosatellite in CERN's CHARM facility, a NIMPH (Nanosatellite to Investigate Microwave Photonics) secondary payload based on the LHC radiation monitoring system (RadMon) and the development of fibre-optic radiation and temperature sensors. In collaboration with the University of Montpellier, CERN expertise has been used for technology demonstrators, such as the microsatellite CELESTA (CERN Latchup Experiment Student Satellite).



A WIDE VARIETY OF APPLICATIONS

CERN's expertise builds broadly on three technical fields: accelerators, detectors and computing. Behind these three pillars of technology lie a great number of areas of expertise (left): from sensors to robotics, microelectronics to superconductivity, and many more. These technologies, and the expertise associated with them, translate into a positive impact on society in many different fields (right).

The start-up company InsightART is using the particle physics pixel detector Medipix to perform highly detailed X-ray scans of artworks such as this painting.

CERN's unique environment combines extremely low temperatures, ultra-high magnetic fields, various types of radiation and high voltages, and thus requires innovative **safety** solutions. A new CERN spin-off company, Neasens, is now developing a network of smart sensors, based on CERN technology, to monitor radon and better tackle risks relating to high radon levels. Radon is produced in the decay processes of natural isotopes and is one of the leading causes of lung cancer deaths, second only to smoking.

Industry 4.0 is the trend of increasing automation and efficiency in manufacturing processes with connected sensors and machines, autonomous robots and big data technology. In 2017, a licence agreement was signed between LG Display and CERN, giving the company access to contro-middleware software originally developed for the LHC, for use in factory automation across its plants.

Several projects relating to **cultural heritage** are also using CERN technologies. One example is the Prague-based start-up company InsightART, which is using Medipix technology in X-ray imaging detectors to inspect paintings in order to assess their condition and identify painted-over or forged works.

Scientists and engineers are working on **emerging technologies** at CERN, particularly in the field of superconductivity. Close industrial collaboration is vital for producing novel high-temperature superconductors, essential for future accelerator developments and, potentially, future energy transportation and storage solutions.

ACCELERATING INNOVATION

The **CERN Knowledge Transfer Fund** acts as a tool to bridge the gap between research and industry, selecting innovative projects based on CERN technology with the potential for a positive impact on society. Since its establishment in 2011, it has funded 41 projects. In 2017, three projects were selected: a compact superconducting magnet for space applications, a compact accelerator for cultural heritage and a 3D laser for carrying out quality control on semiconductor devices. In addition, the **CERN Medical Applications Budget** funded 11 new projects and five new trainees, PhD students and fellows.

Convened and managed by CERN, **SCOAP³** (Sponsoring Consortium for Open Access Publishing in Particle Physics) is a global open-access initiative involving 3000 libraries, funding agencies and research institutions from 47 countries. Since it began in 2014, it has made 15 000 articles by some 20 000 scientists from more than 100 countries accessible to everyone. In April, CERN and the American Physical Society signed an agreement according to which, as of January 2018, all authors worldwide will be able to publish high-energy physics articles in *Physical Review C*, *Physical Review D* and *Physical Review Letters* at no direct cost. This extends SCOAP³ to cover almost 90% of the journal literature in the field.

THE GLOBAL OPEN-ACCESS INITIATIVE SCOAP³ MAKES ALMOST 90% OF HIGH ENERGY PHYSICS JOURNAL ARTICLES ACCESSIBLE TO EVERYONE.

FRUITFUL COLLABORATIONS

CERN engages with international organisations and participates in European Commission co-funded projects, five of which have a strong knowledge transfer component. Alongside AIDA-2020 in 2015 and QUACO in 2016, three new projects began in 2017: ARIES, AMICI and FuSuMaTech.

ARIES is designed to improve the performance, availability and sustainability of particle accelerators, transferring the benefits and applications of accelerator technology to both science and society, and enlarging and integrating the European accelerator community. AMICI aims to consolidate and exploit this infrastructure across the accelerator community, strengthening the capabilities of European companies to compete on the global market. FuSuMaTech aims to establish a sustainable research, development and innovation network across Europe to structure and strengthen the field of superconducting magnets and the associated industrial applications, with potential applications in neuro-imaging.

FOSTERING ENTREPRENEURSHIP

To develop a **culture of entrepreneurship** at CERN and increase the number of start-ups using CERN technologies, 2017 saw the fiftieth entrepreneurship meet-up since the initiative began more than two and a half years ago. In addition, CERN has established a network of nine Member State Business Incubation Centres (BICs) to assist entrepreneurs and small businesses in taking CERN technologies and expertise to the market. Five new start-ups were accepted into a BIC in 2017. Beyond the BIC network, the Knowledge Transfer group supports spin-offs and start-ups through a variety of different activities and mechanisms, from licensing of technologies to business plan development and access to training programmes. To date, there are 23 start-ups and spin-offs using CERN technology.

A RETURNED INVESTMENT

By the nature of its activities and its structure, CERN requires a wide range of goods and services. Half of its annual budget of one billion Swiss francs returns to industry through procurement (see p. 53). In the case of high-level technological goods, contracts with CERN can boost innovation in industry. In 2017, some 782 price enquiries, 98 invitations to tender and 63 000 orders were made, including those through the CERN Stores. Contracts ranged from the purchase of data-centre infrastructure for ALICE and LHCb to the assembly of 11-tesla dipole magnets for the HL-LHC and services such as the maintenance of the cooling and ventilation system on the CERN site.

Through its dedicated procurement service, CERN targets balanced industrial returns. In practice, this is done by holding industrial exhibitions at CERN, attending industry events in Member and Associate Member States, and generally working towards creating strong links with national industries. Limited tendering – where invitations to tender are limited to countries with very poor industrial returns – is also used to improve industrial return.

CERN PROCUREMENT: A LARGE NUMBER OF ACTIVITIES

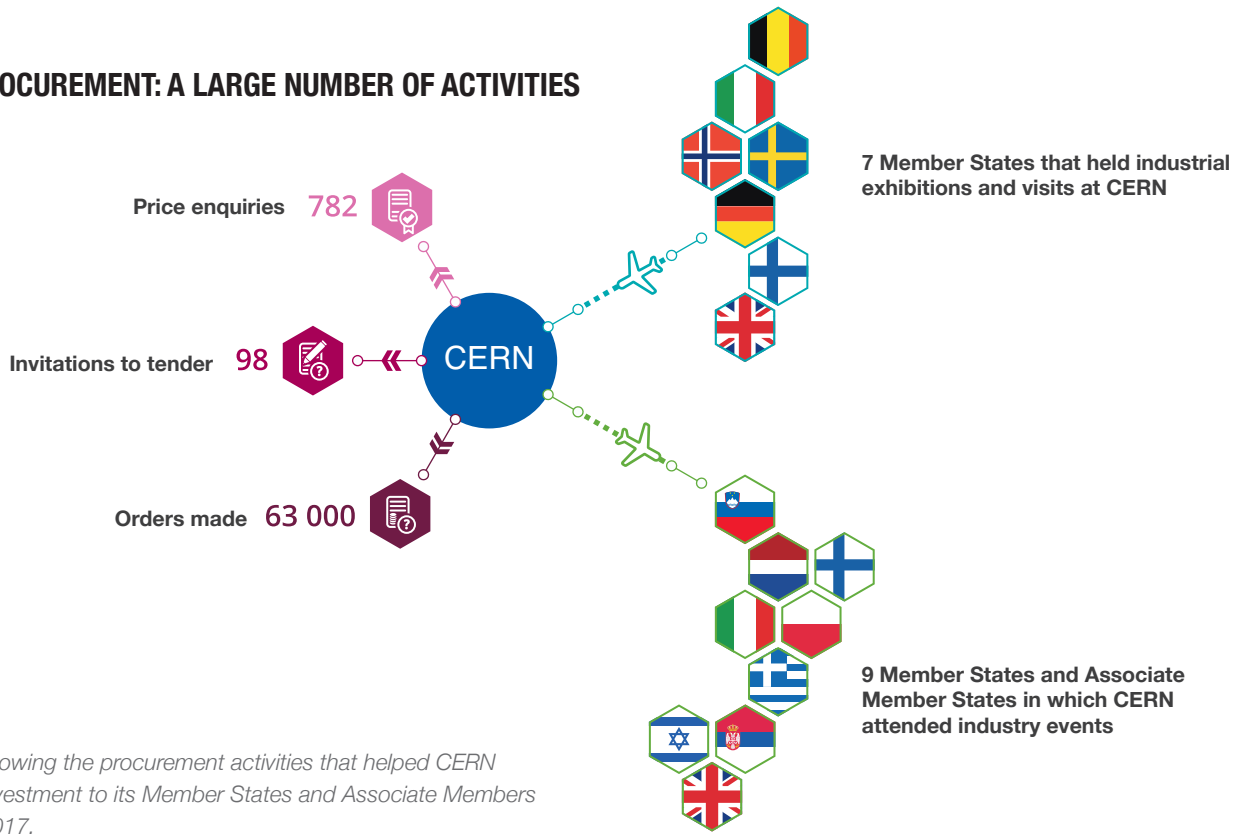


Diagram showing the procurement activities that helped CERN to return investment to its Member States and Associate Members States in 2017.