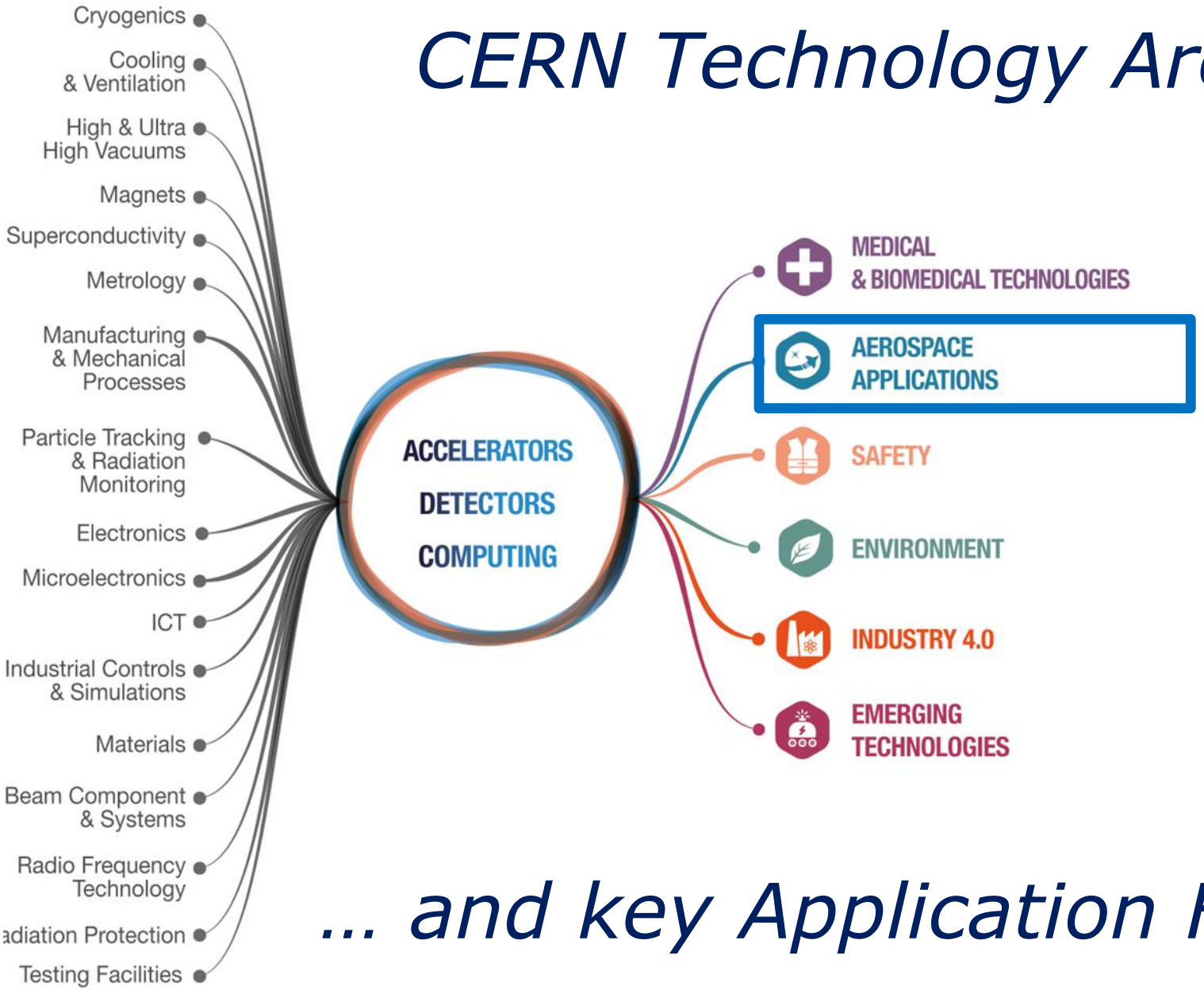
CERN's Aerospace Applications and Small Sat Projects

Enrico Chesta
CERN
Knowledge Transfer Group
Aerospace Applications

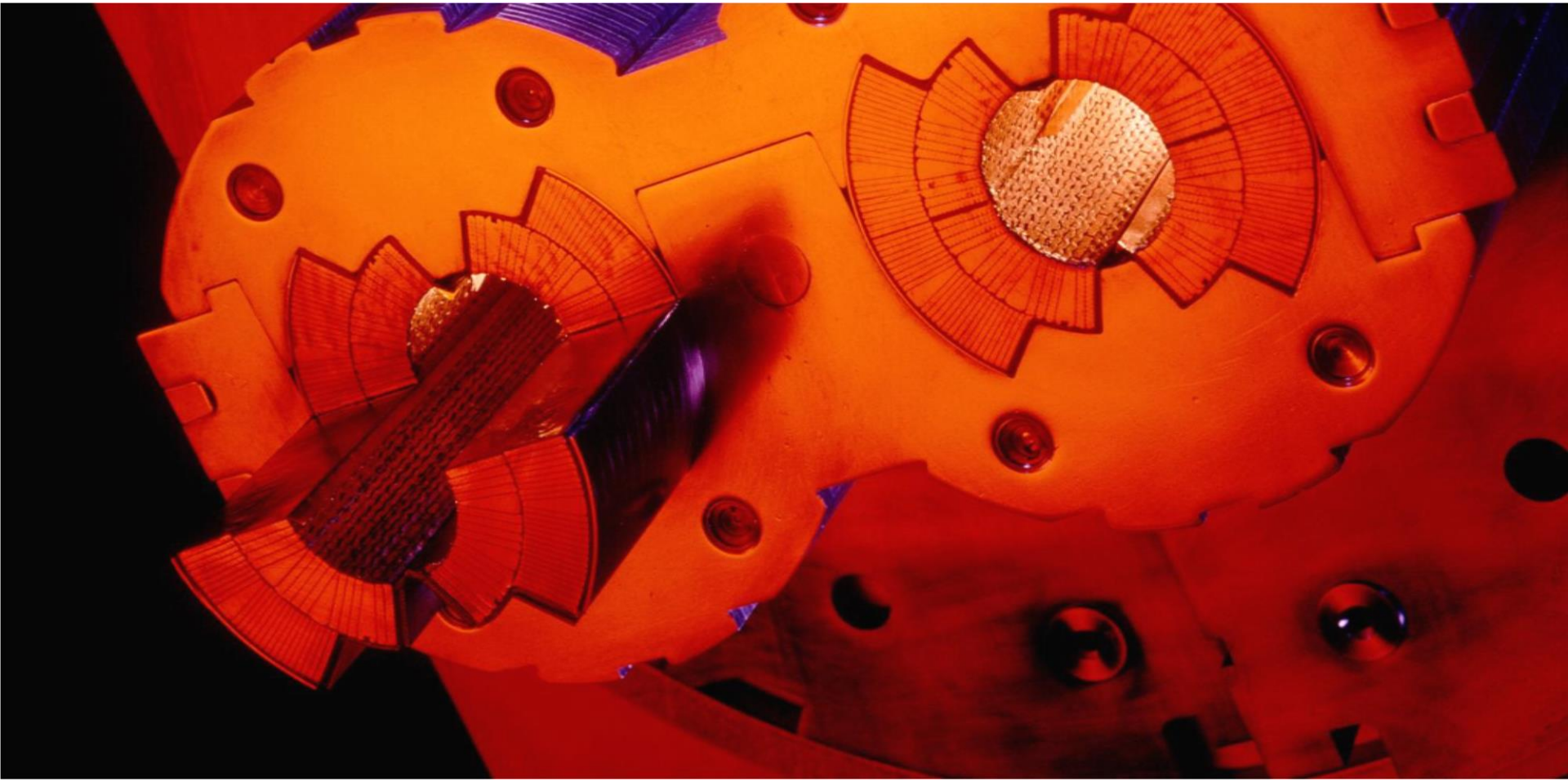
Nanosat Student Initiative Brainstorming Meeting

CERN Technology Areas…



… and key Application Fields

Very high vacuum

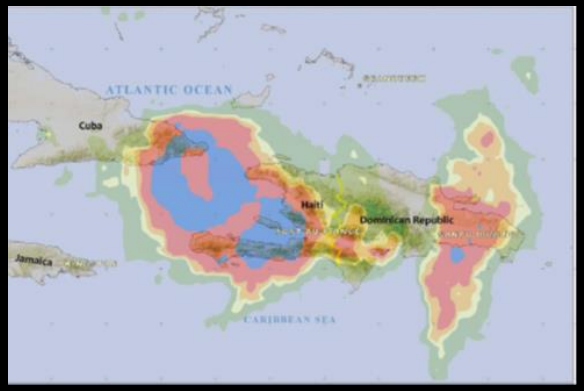


Extreme temperatures

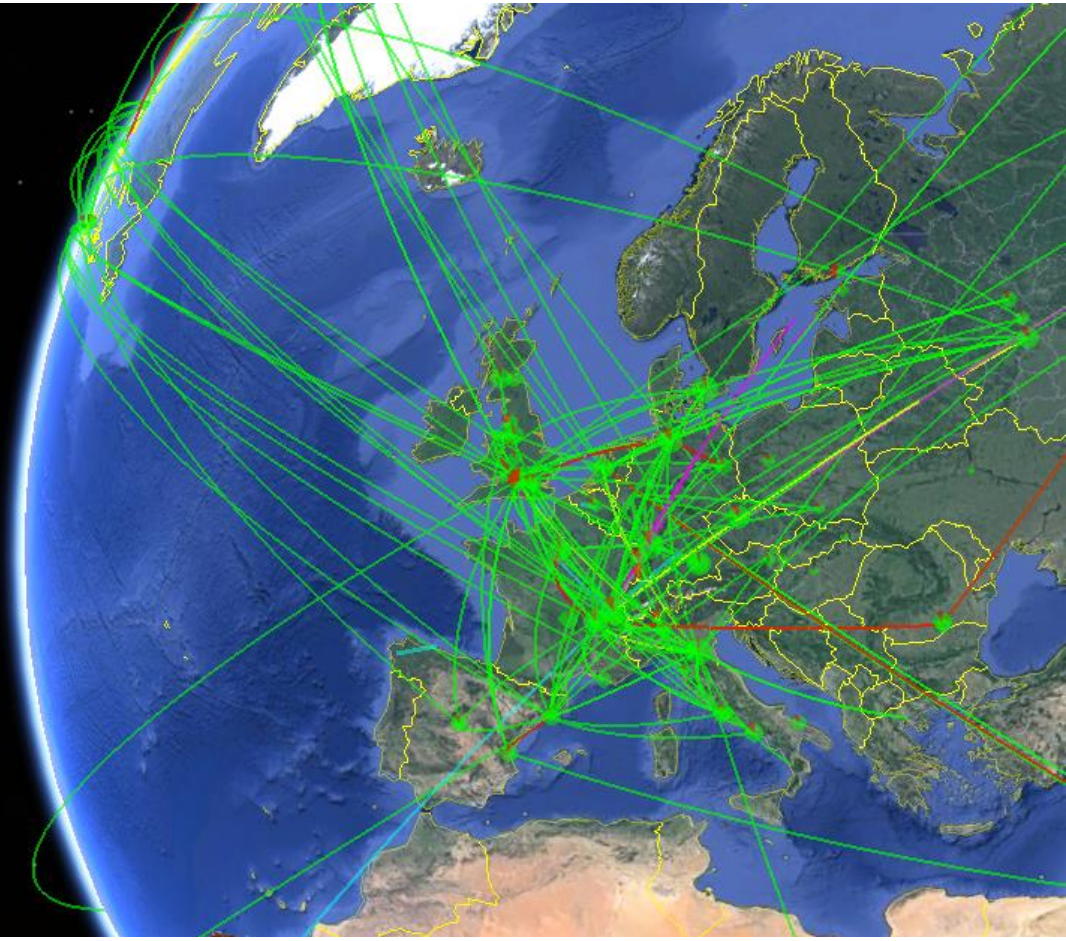
Radiations

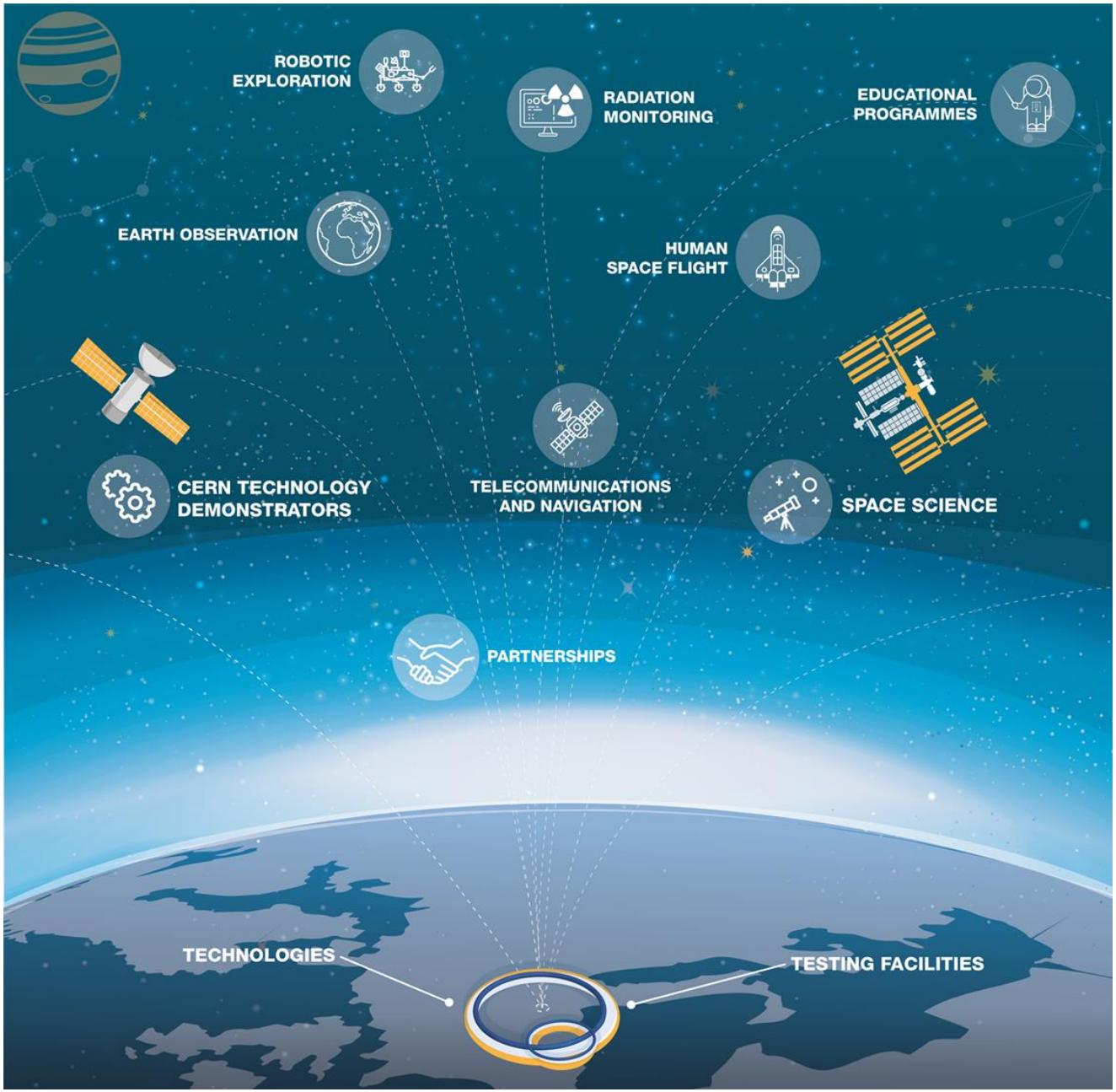

RADIATION
ZONE
SURVEILLÉE
SUPERVISED
AREA
Dosimeter obligatory
Dosimètre obligatoire
Radiation Protection
Radioprotection
72504

Big data

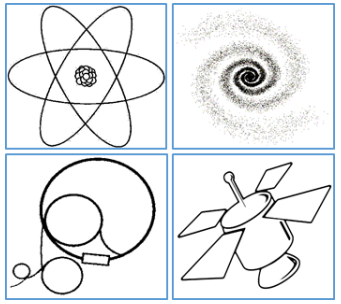


Collaboration with UNITAR-UNOSAT

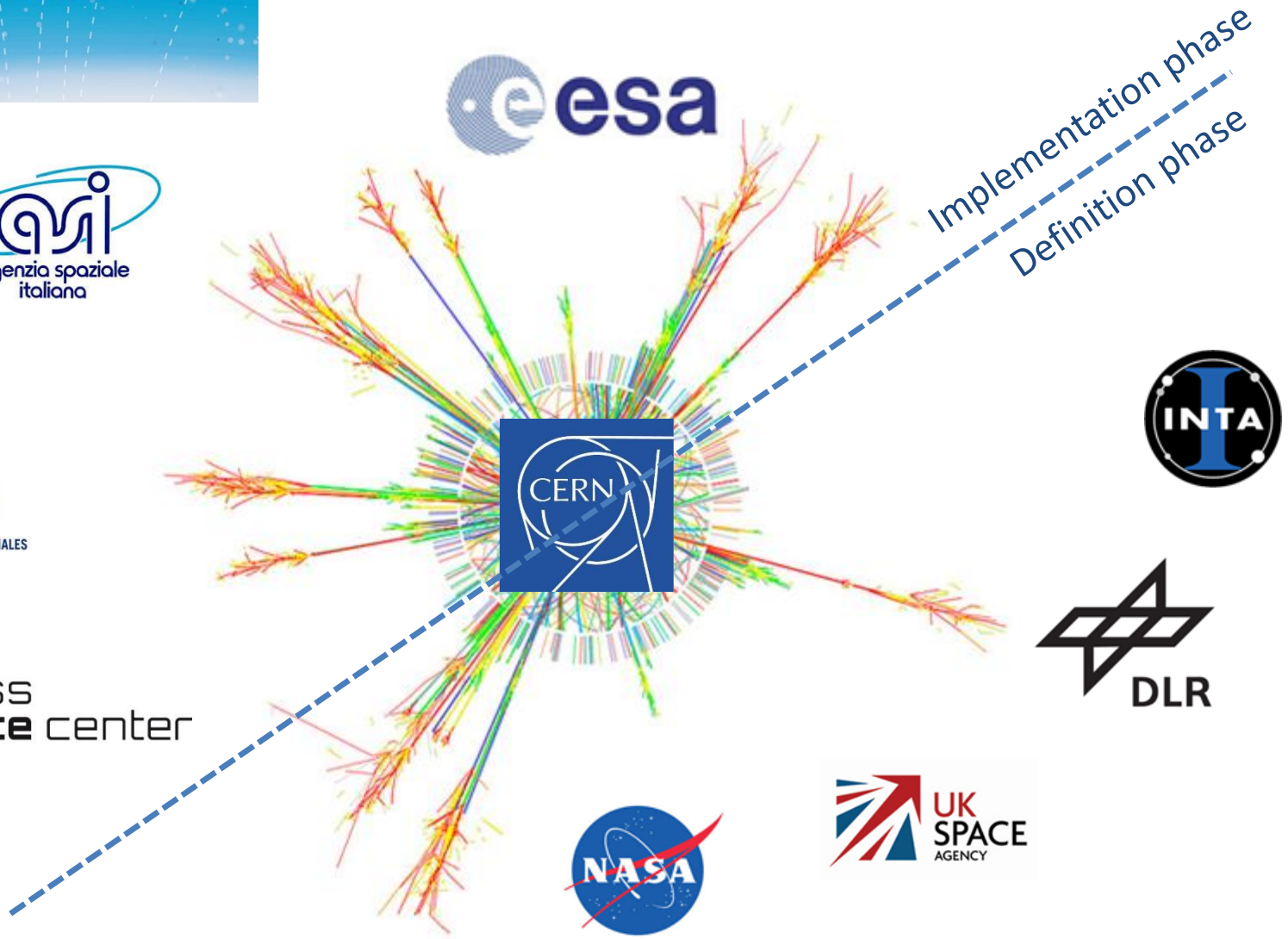




CERN AEROSPACE APPLICATIONS



Institutional Cooperation



CERN-ESA Cooperation

Geneva, 28/03/14
Signature of CERN-ESA co-operation agreement:

"CERN and ESA have common roots and share a long history of pioneering research work in their respective fields. This new cooperation agreement will foster synergies between the expertise, know-how and facilities available in the two Organizations."

- 12 identified technology areas under assessment to identify bilateral collaborative projects
- Implementing protocol signed on 11/07/19 in the field of «Radiation Environments, Technologies and Facilities » - 7 specific projects

CERN's Value Proposition for Aerospace

https://cernbox.cern.ch/index.php/s/8vyxln9xa8Z6n0s

DATA ANALYTICS
CERNs knowhow and experience with 'big data' analysis for high energy physics and control of systems used in the LHC.

HIGH VOLUME DATA MANAGEMENT & STORAGE
CERN's unique knowhow derived from storage and worldwide distribution of vast amounts of data

MACHINE LEARNING & DEEP LEARNING
Knowhow and experience derived from early adoption of neural network techniques by particle physics community

HIGH & ULTRA-HIGH VACUUM SYSTEMS
Expertise in the design, construction and operation of one of the largest and most complex vacuum systems in the world

CRYOGENICS
CERN's unique knowhow derived from 60 years of designing, installing and operating the world's largest cryogenics installation

MANUFACTURING AND MECHANICAL PROCESSES
CERN develops manufacturing solutions for machines operating at the limits of precision, size, speed and power

MATERIAL SCIENCE
Novel fabrication methods and analysis procedures for materials operating at the extremes of precision and endurance

METROLOGY
Unique know-how derived from the precise construction and operation of some of the world's largest and most complex machines

OPTOELECTRONICS & MICROELECTRONICS
CERN's unique know-how derived from years of designing, testing and installing microelectronics exposed to harsh environments.

PARTICLE TRACKING & CALORIMETRY
CERN's unique know-how derived from years of designing, testing, building and operating complex detector systems.

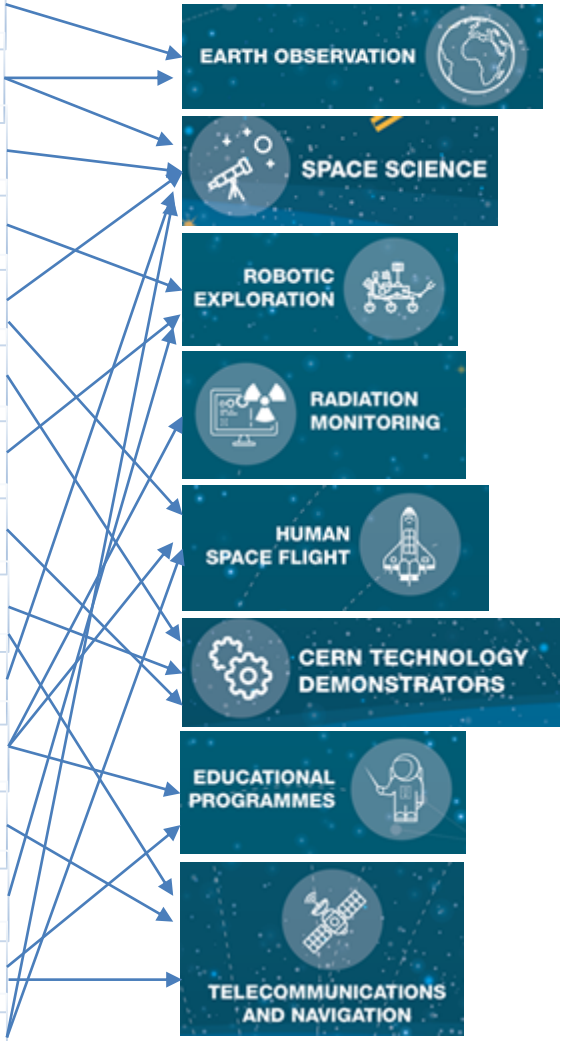
RADIATION PROTECTION & MONITORING
CERN's unique knowhow derived from years of designing, installing and operating systems to monitor level of radiations.

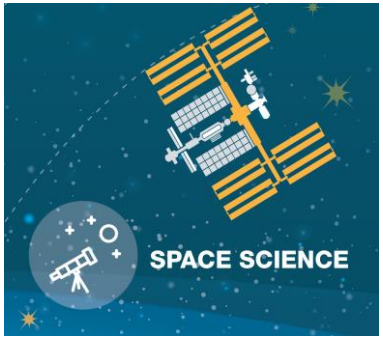
RADIO FREQUENCY TECHNOLOGY
Expertise in the design, construction, maintenance and upgrade of one of the most complex operational RF systems in the world

ROBOTICS
CERN's unique knowhow in designing, building, operating robotics systems for interventions in harsh environments

SENSORS
CERN's unique knowhow derived from years of developing, using, characterizing a large amount of sensors.

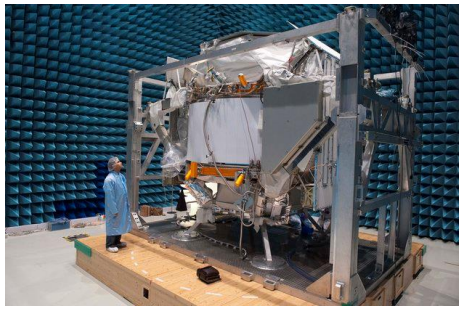
SUPERCONDUCTING MAGNETS
CERN's knowhow and facilities for end-to-end design, assembly, testing and operation of superconductive magnet systems





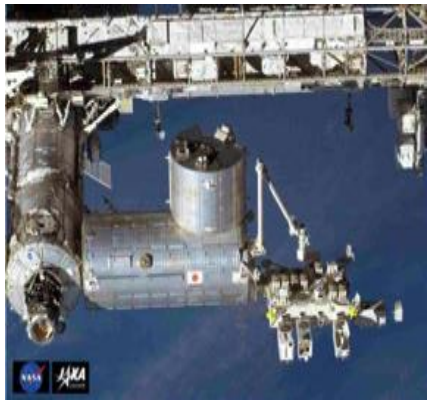
CERN Supported Scientific Experiments in Space - Examples

Astroparticle Physics – Astrophysics - Cosmology

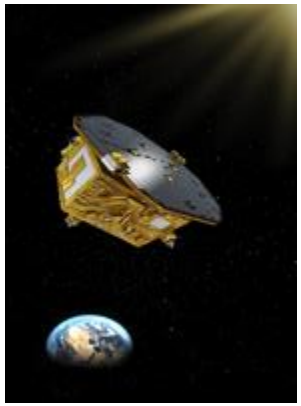


AMS-02

Nucleon

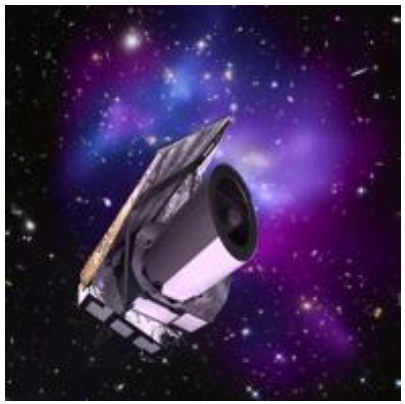


CALET



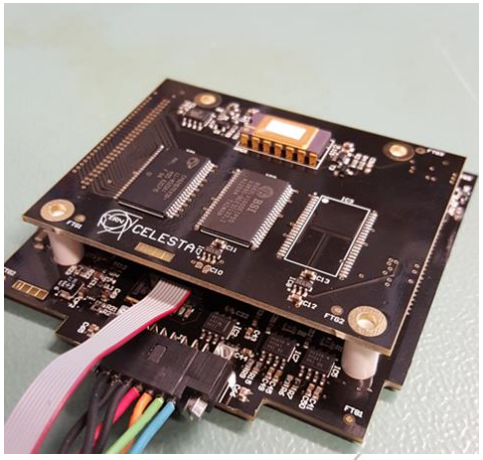
LISA Pathfinder

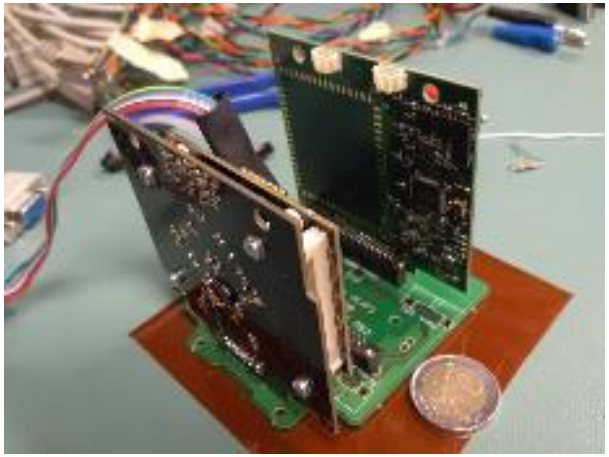
DAMPE

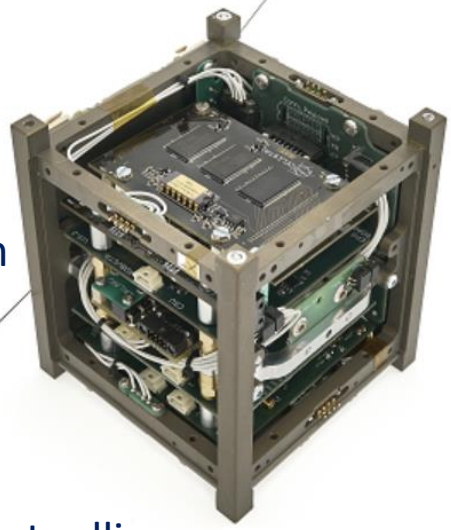


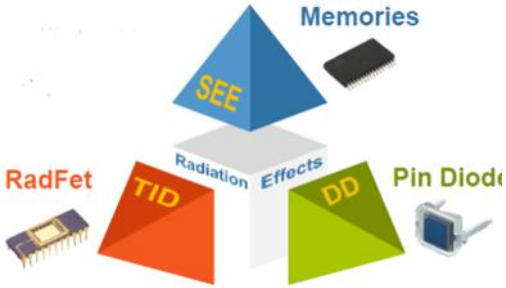
EUCLID

CELESTA – First CERN driven nanosat





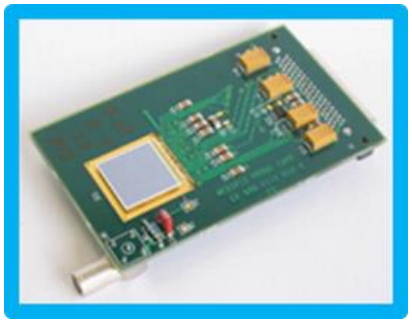


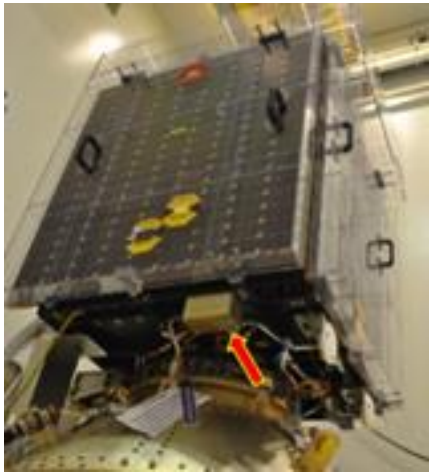


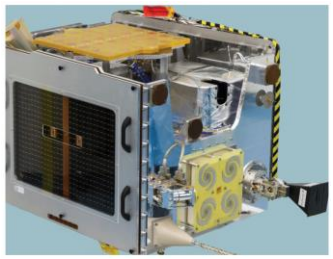
Objectives:

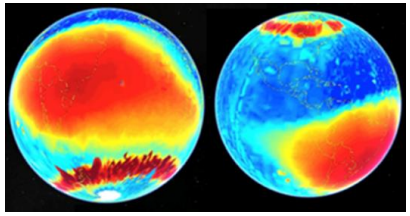
- Technological
  - SpaceRadMon space demonstration
  - CHARM ground validation
- Scientific
  - Radiation monitoring
- Educational
  - Collaboration with University of Montpellier
  - Selected by ESA Fly Your Satellite programme for launch in 2020

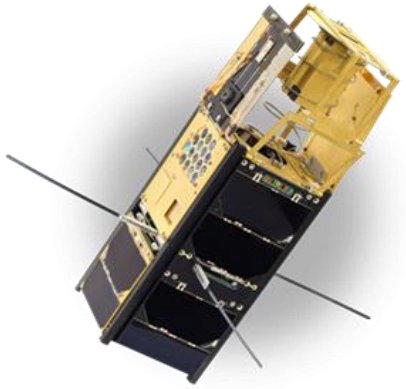
CERN's technologies in small satellites







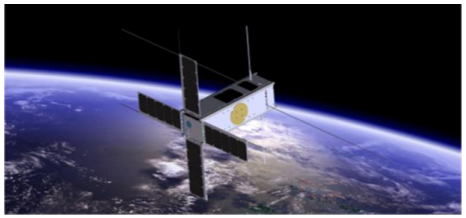




Completed/ongoing:

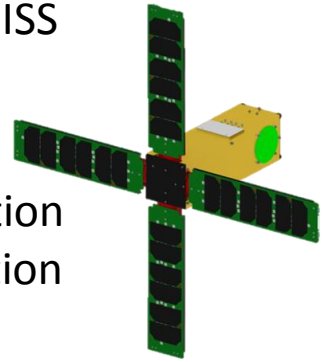
Timepix in-flight demonstration on PROBA-V (SATRAM, 2013), TechDemoSat-1 (LUCID, 2014-17), Orion EFT-1 (BIRD, 2014), VZLUSAT-1 (miniaturized X-ray telescope, 2017), ISS

In preparation:

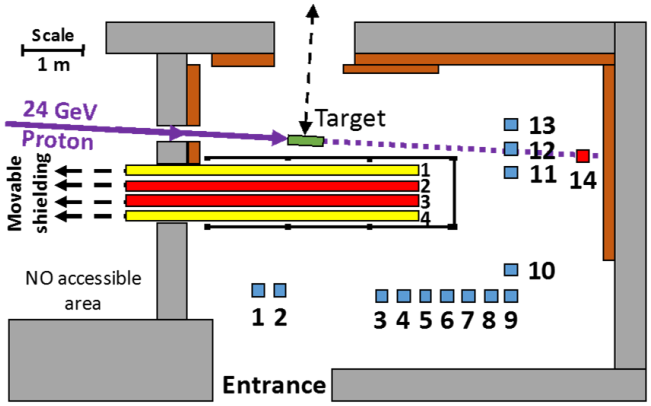


SpaceRadMon on NIMPH, IODA, TAUSAT

EyeSat radiation characterization in CHARM



Unique Irradiation Facilities

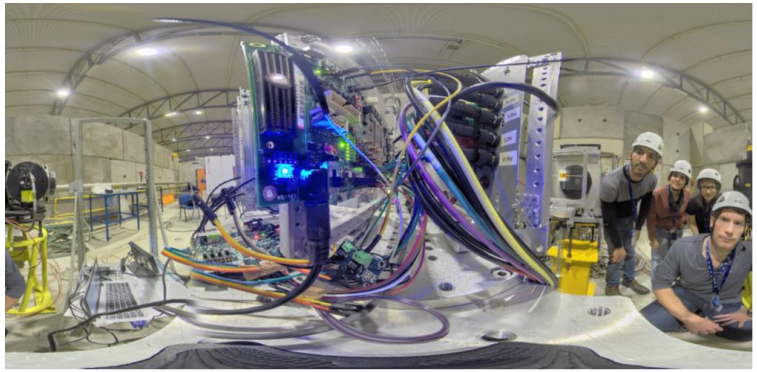


CHARM

CERN High energy AcceleRator Mixed field/facility

VESPER

Very energetic Electron facility for Space Planetary Exploration missions in harsh Radiative environments



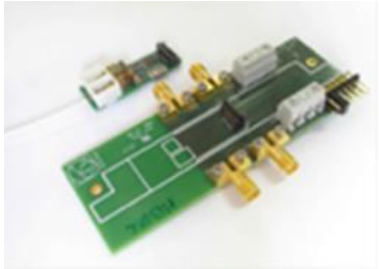
SPS North Area

Ultra High Energy Heavy Ions test line

CERF

CERN-EU high-energy reference radiation facility

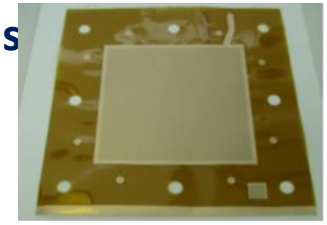
Exemples of CERN Technologies for Space



HTS magnets

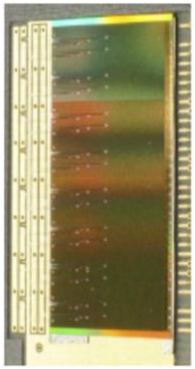
Rad-hard electronic devices for power distribution and high speed optical links

Micro-engineering and advanced material solutions for thermal management



Expertise and data-base on COTS for space and rad-tol electronics

Detector technologies based on Monolithic Active Pixel Sensors (MAPS) or Gas Electron Multipliers (GEMs)



Data handling - analysis software and AI algorithms

CernVM File system

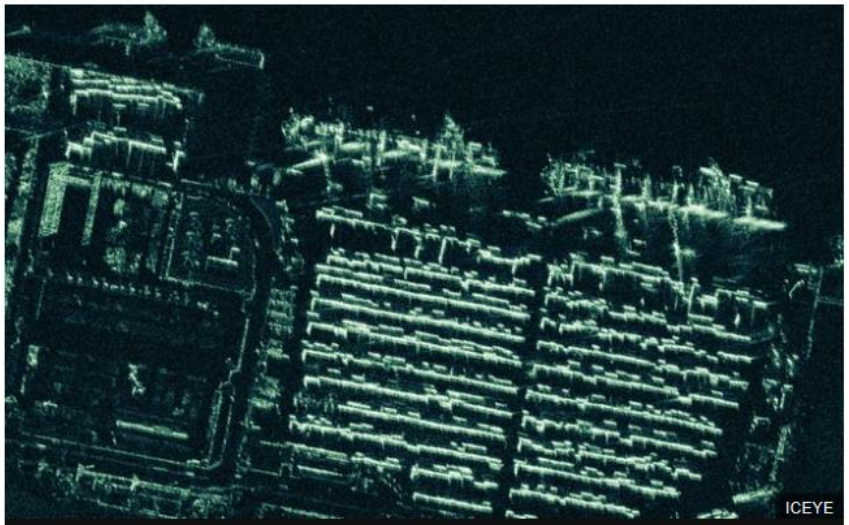
ROOT Data Analysis Framework

Exemple of COTS application to Earth Observation

Iceye satellites return super-sharp radar images

By Jonathan Amos
BBC Science Correspondent

9 August 2019 Share



A container terminal near Port Harcourt, Nigeria: detail under a metre across is visible to the radar

Finnish space start-up Iceye has once again given an impressive demonstration of its novel technology's capabilities.

The company's radar satellites are now returning sub-1m resolution images of the Earth's surface.

This level of performance is expected from traditional spacecraft that weigh a tonne or more and cost in excess of one hundred million euros.

But Iceye's breakthrough satellites are the size of a suitcase and cost only a couple of million to build.

World Leading Earth Imaging Technology

Synthetic-aperture radar is an Earth observation technology which takes pictures of both land and sea, without the need for sunlight or the need for clear skies.

ICEYE's Synthetic-aperture radar instrument has been developed by ICEYE, using the latest technology and design philosophies in the world. ICEYE-X1, the world's first under 100 kg SAR satellite to deliver on orbit images from space, was launched in January 2018, marking a new era for the synthetic-aperture radar imaging industry. By design, it is a platform agnostic instrument, meaning it can also be integrated into systems other than spacecraft, such as airplanes.

"SAR on smallsats? Unthinkable a few years ago. ICEYE has done it."
- Josef Aschbacher, Director of Earth Observation, European Space Agency.

As the SAR instrument design of ICEYE actively incorporates components commercially available off-the-shelf as a natural part of the process, ICEYE is able to push the boundaries of what was previously thought possible. By incorporating a New Space approach, ICEYE has been able to reach a necessary technological threshold of surviving the harsh environment of space, without being limited to technology created many years ago.

Exemple of AI application to Earth Observation

ESA subjects artificial-intelligence chip to tests at CERN

Intel's new Myriad 2 chip underwent tests at the SPS accelerator to simulate conditions experienced in space

4 DECEMBER, 2018

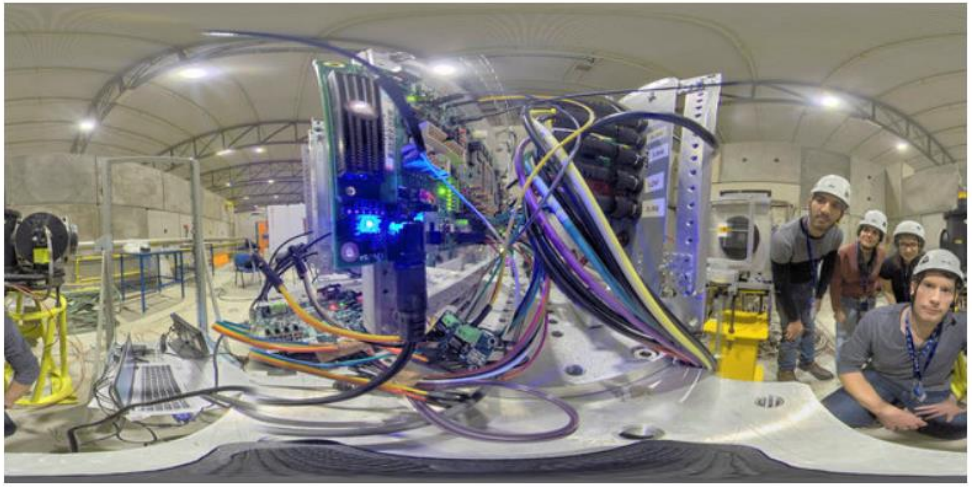
The Myriad 2 chip (Image: Maximilien Brice/CERN)

An ESA-led team subjected Intel's new Myriad 2 artificial intelligence (AI) chip to one of the most energetic radiation beams available on Earth: the lead-ion beam delivered by CERN's Super Proton Synchrotron (SPS) accelerator.

The Myriad 2 harnesses artificial intelligence for high-performance, low-power vision processing. It can be pre-trained with data to recognise particular features and patterns or perform in-depth 3D sensing. ESA engineers are interested in harnessing the Myriad 2 to perform in-orbit image processing on future space missions, reducing the amount of data that needs to be sent back to Earth.

"AI is a way of boosting the performance of any system with a camera in the loop," explains ESA on-board computer engineer Gianluca Furano. "By autonomously figuring out the distance of an object from a camera and how fast it is moving it can take many more and better images. This also offers a means of enhancing guidance, navigation and control – for instance to capture drifting items of space debris.

"And it could let us overcome the performance bottleneck faced by imaging instruments on CubeSats and other small satellites. Low data-downlink bandwidth due to a small antenna size and limited power levels stops us accessing all the imagery we could acquire. The Myriad 2 requires less than a watt of power, and would also let instruments identify features of interest autonomously – for instance, spotting sudden flood events or forest fires, then realising these need to be sent down to the ground."



360 view of Myriad 2 testing at CERN

ESA TEAM BLASTS INTEL'S NEW AI CHIP WITH RADIATION AT CERN

29 November 2018 An ESA-led team subjected Intel's new Myriad 2 artificial intelligence chip to one of the most energetic radiation beams available on Earth. This test of its suitability to fly in space took place at CERN, the European Organization for Nuclear Research. The AI chip is related in turn to an ESA-fostered family of integrated circuits.

The Myriad 2 harnesses artificial intelligence for high-performance, low-power vision processing. It can be pre-trained with data to recognise particular features and patterns or perform in-depth 3D sensing, whatever its customer requires.

For more informations:

www.cern.ch/kt/aerospace

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