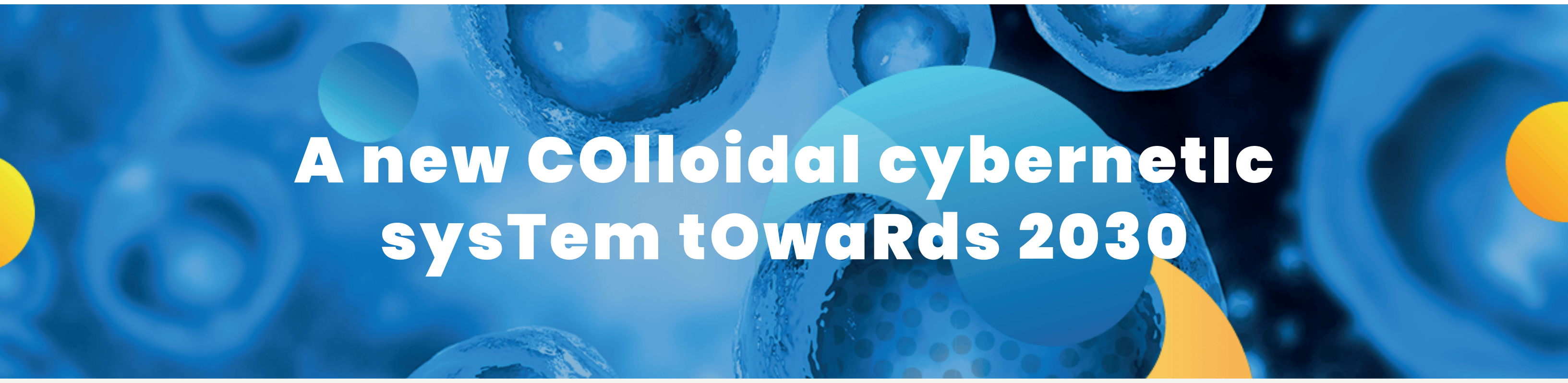


A new COlloidal cybernetIc sysTem tOwaRds 2030

Farewell by the coordinator

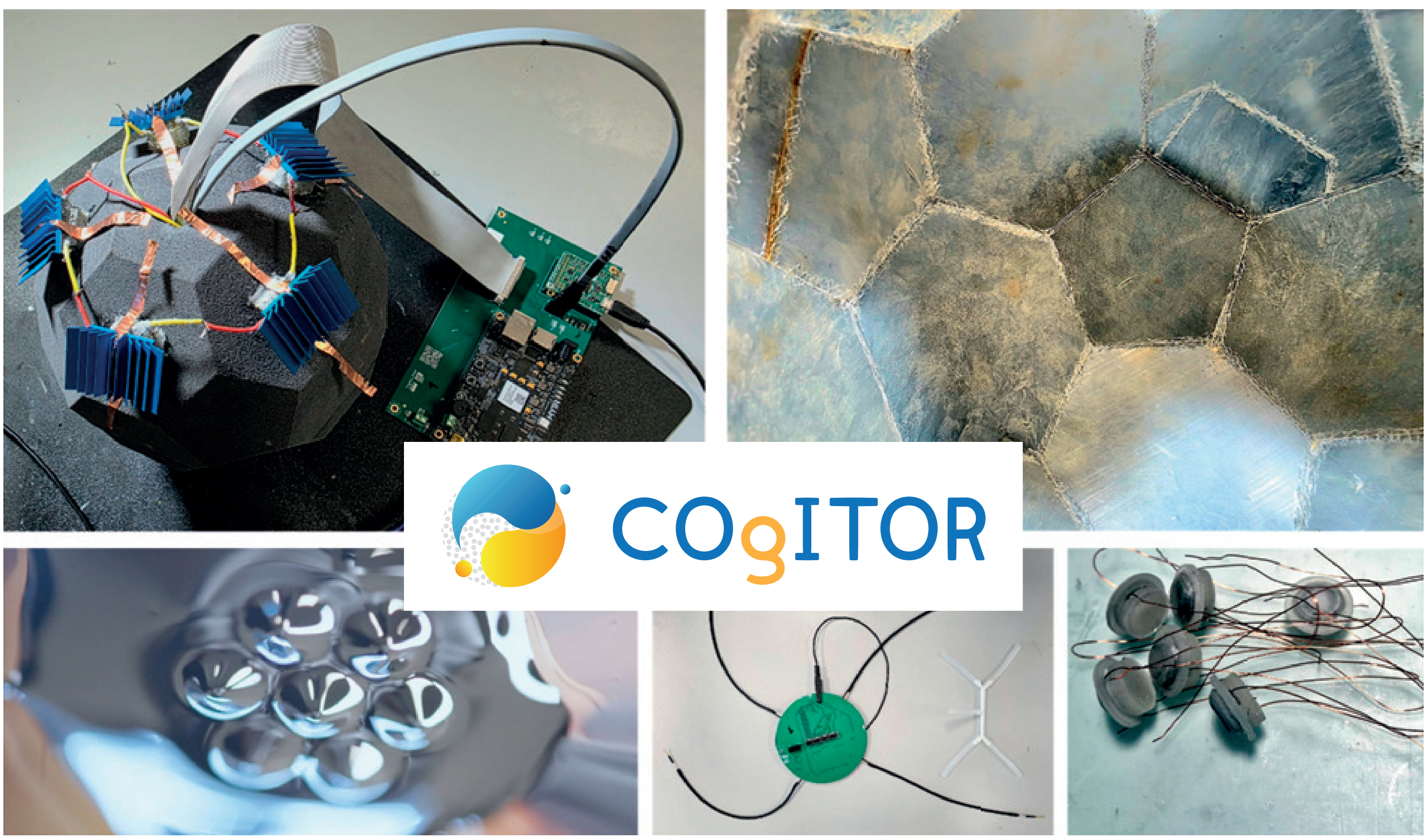
The COgITOR project has reached its end, with the successful integration and testing of the prototype of the first Colloidal Cybernetic System (CCS) in Genova, Italy. This convergence marks the last milestone, achieved through the joint efforts of Istituto Italiano di Tecnologia, the University of the West of England, Empa, École Polytechnique Fédérale de Lausanne, PlasmaChem and PNO Innovation. The CCS embodies a new paradigm in system engineering and unconventional computing, integrating a liquid-based memory and computing core driven by microwave impedance spectroscopy, powered by thermogalvanic energy harvesters, featuring piezoresistive soft pressure sensors, and a self-healing polymeric skin.

Recent integration and testing activities have demonstrated that the system is not only operational but exhibits intrinsic robustness at both material and architectural levels. The colloidal computing core maintains stable and reproducible behavior under a wide range of perturbations, including thermal, mechanical, and electromagnetic stimuli, confirming its fault-tolerant nature. At the same time, the self-healing skin enables recovery of integrity after mechanical damage, restoring system-level operation close to baseline conditions. Importantly, interference assessment tests have shown that sensing, energy harvesting, and computation can operate simultaneously without detrimental cross-coupling, validating the effectiveness of the system design.

The final testing campaign has focused on challenging the CCS under extreme environmental conditions, including ionising radiation, magnetic fields, high pressures and temperatures. The environmental conditions adopted in this work do not correspond to a single naturally occurring extraterrestrial environment, but rather to a compounded stress envelope inspired by multiple space-relevant scenarios. For example elevated pressures and moderate temperatures are representative of dense planetary atmospheres and subsurface niches (e.g., Venusian cloud layers or icy moon interiors), while high-energy particles are characteristic of deep space and planetary magnetospheres. Strong magnetic fields, although rarely co-located with such thermobaric conditions, are relevant in the vicinity of magnetized bodies.

The experiments have also highlighted current technological bottlenecks. In particular, failures associated with sealing, wiring, and ancillary materials indicate that future developments must address system-level engineering constraints rather than core functional principles. These results provide a clear roadmap for advancing CCS toward real-world deployment in demanding environments.

As the project concludes, COgITOR establishes a strong foundation for the future of liquid cybernetic systems, demonstrating that computation, sensing, and energy harvesting can be unified within adaptive, self-healing, and resilient architectures.



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