Project title	A new COlloidal cybernetIc sysTem tOwaRds 2030		
Project acronym	COgITOR		
Project number	964388		
Call	FET Open – Novel ideas for radically new Technologies	**Call ID**	2020-FETOPEN-2018-2019-2020-01
Topic	FET-Open Challenging Current Thinking	**Topic ID**	FETOPEN-01-2018-2019-2020
Funding scheme	Research and Innovation Action		
Project start date	01/06/2021	**Duration**	54 months

INFORMAL DISSEMINATION & COMMUNICATION

ACTIVITIES STATUS UPDATE

Work package	Wp6
Responsible Author(s)	CTECH
Contributor(s)	ALL

Dissemination level

Please select only one option according to the GA			
☒	PU: Public	☐	PP: Restricted to other program participants
☐	RE: Restricted to a group specified by the consortium	☐	CO: Confidential, only for members of the consortium

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Dissemination & Communication project status update (M18)

The Deliverable 6.3 “Dissemination and Communication plan” was delivered as planned in M6 and all dissemination activities done in the reference period were properly tracked and reported in the EU Reporting platform. In this document, the main aim of the communication and dissemination plan is indicated as follows:

a. To inform and engage with relevant stakeholders and selected target groups about the activities and results of the project. Whenever possible, a two-way communication approach will be used with stakeholders and early adopters of the technology proposed

b. To raise awareness about the project itself and project results

c. To share and align the knowledge developed in the initiative with different stakeholders, especially industrial stakeholders, including industrial associations (i.e. EUnited Robotics), as well as scientific community, European Networks and Associated Partners, and other (EU-) funded projects in the fields of soft robotics/electronics, colloidal Science and Technology, nanotechnology, analytic tools, nanomedicine, bio-nanotechnology)

The plan will be regularly updated to be able to respond to new opportunities and promptly monitor progress and updates about D&C.

The purpose of the communication and dissemination plan is to define in detail:

1. The communication and dissemination strategies adopted

2. The available communication and dissemination channels and tools

3. The major stakeholders and targets groups to focus on, in synergy with what will be implemented under task 6.4 (Stakeholder analysis), in collaboration with the whole consortium

4. A planning and timing of the dissemination activities

5. Guidelines and templates for partners to disseminate and communicate about the project results.

The dissemination plan has been tailored for each target group to optimize its effectiveness. It must be emphasized that dissemination is a continuous process, and it will last for the entire project duration.

More in detail, as indicated in the GA, the scientific dissemination was managed by all partners under the CTECH leadership. The most appropriate journals and conferences\events were identified and selected, monitoring both open access publication of results on international peer-reviewed high-impact journals and participation in international conferences to give visibility to achieved results.

As an example, the Journal of Colloids and Interface Science (paper submitted in referage), Physical Chemistry – Chemical Physics, Advanced Materials (paper submitted in referage), and Scientific Reports (paper submitted in referage), is a choice of high-impact journals.

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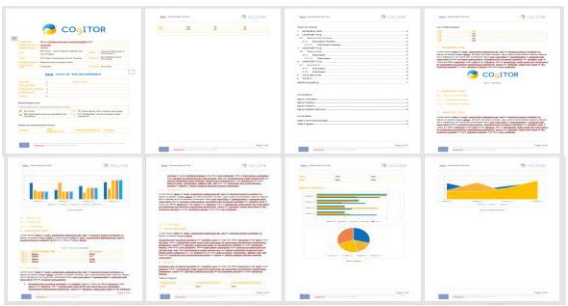
Nevertheless, all of our results have been published as pre-prints in archives, such as ArXiv and/or ResearchGate, to grant access and readability from anybody free of subscription fees.

Website, logo, social networks, videos, outreach package

The project Website, logo, social networks, and outreach package were set in place by CTECH and were maintained alive thanks also to partners' contributions. **In the first 18 months of the project, the following activities were realized as part of the analytic D&C project strategy deployment.**

THE WEBSITE

The **website** must be considered the focal point of external dissemination and internal communication within the consortium: it was released as planned at M2, and it is continuously updated. At M2 the project **visual identity** was entirely created, and the style guide was implemented, together with a project logo. The D6.1 "Project logo and website" was delivered as planned in M2 and at the same time, it was also elaborated powerpoint, and word **templates** to be used by partners.



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COgITOR SOCIAL MEDIA ACCOUNTS

Social media project accounts (LinkedIn and Twitter) were opened at M2, to attract a wider audience, and direct links to them were also provided on the website homepage. During the first 18 months of activity, 75 posts were published and/or where the project was tagged, to boost the COgITOR visibility. 17 other types of updates were also released on the corporate websites and newsletters of the partners with the same aim.

THE DISSEMINATION AND COMMUNICATION MATERIALS

The **D&C materials** were implemented at M6, namely a brochure, a poster, and two versions of roll-up. The materials can be found on the website page "public document" available here https://www.cogitor-project.eu/public-documents/. They display the project's main features, impact, benefits and objectives, partners' logos, contacts, and EC acknowledgment. **At M12, as indicated in the D6.3 D&C Plan, these materials were updated** with the first-year project results achieved. They can be found, as well, on the page above-mentioned.

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THE NEWSLETTERS

As planned on the D&C plan, every six months a **newsletter** was prepared. Three newsletters were therefore released in the first 18 months, they were published, released on the social project channels, available on the website, and distributed via CTECH/PNO channels and other partners' too. More in detail:

1. The first one, issued in November 2021, presented the project partners, and it is available here https://www.cogitor-project.eu/wp-content/uploads/2021/11/Cogitor-Newsletter01.pdf
2. The second one, issued in May 22, analyzed the first-year project results and it is available here https://www.cogitor-project.eu/wp-content/uploads/2022/06/Cogitor-Newsletter-02-.pdf
3. The third one, issued in November 2022, was intended to share the last technical and non-technical updates and the latest results & achievements of COgITOR project, and it is available here https://www.cogitor-project.eu/wp-content/uploads/2022/12/Cogitor-Newsletter-03-final.pdf

ISSUE N. 1: November 2021

ISSUE N. 2: May 2022

ISSUE N. 3

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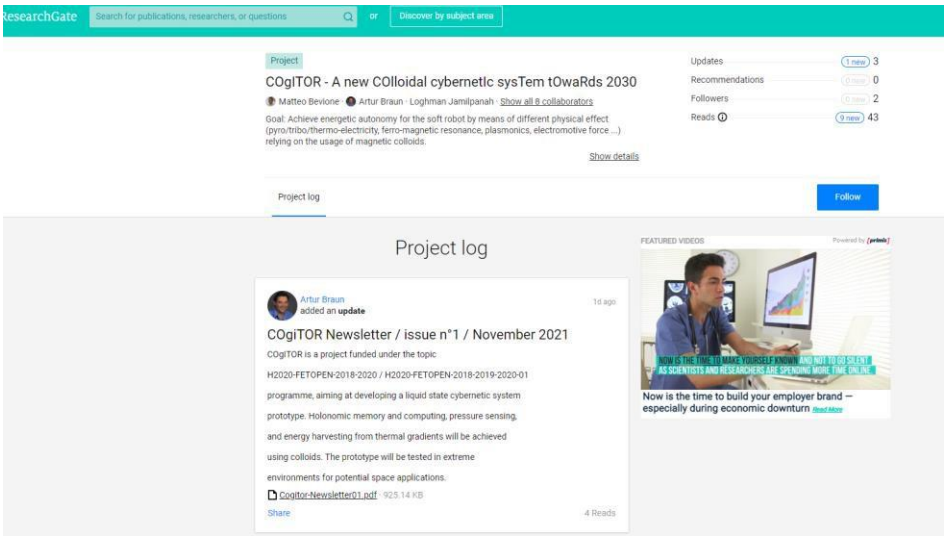
COgITOR on RESEARCHGATE

As part of the D&C strategy, COgITOR was also included on **RESEARCHGATE**: ResearchGate is a European commercial social networking site for scientists and researchers to share papers, ask and answer questions, and find collaborators. It was started in 2008 to address the problems researchers saw in the way science was created and shared. Its mission is to connect the world of science and make research open to all. The 20 million researchers in the ResearchGate community come from diverse sectors in over 190 countries, and use this tool to connect, collaborate, and share their work. The relevant link can be found here https://www.researchgate.net/project/COgITOR-A-new-COlloidal-cybernetIc-sysTem-tOwaRds-2030



On a national level, the project was mentioned on the Italian Open Innovation Platform of Regione Lombardia, where an article was dedicated to the project

https://www.openinnovation.regione.lombardia.it/it/b/572/ecco-cogitor-primo-robot-liquido-per-esplorare-abissi-e-pianeti

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PRESS RELEASES

A Wide and extensive effort was devoted to the project launch through the publication of **press releases**, reaching out to more than 9 million people: it was managed by IIT and, on the website, a report about this action was published, it can be found at the following links.

- COgITOR Launch: coordinator press release (web version)
- COgITOR press releases following the project launch
- COgITOR national and international press releases: from September to December 2021

EVENTS

Many **events**, despite the pandemic COVID-19, were attended by the project partners:

- **CTECH** attended Ecomondo 2021 and Ecomondo 2022. This last edition was promoted with 13 social media posts, 4 news on websites and newsletters, with 24094 general public reached, and 250 flyers distributed.
- **IIT** gave a presentation about self-healing skin in the plenary meeting of Bioinspired Soft Robotics Group in Genoa; the coordinator gave a speech in 13th International Conference on Physics of Advanced Materials (ICPAM-13) and the 4th Autumn School on Physics of Advanced Materials (PAMS-4) in Romania; IIT organized also Bilateral meeting at Università degli Studi di Salerno, Fisciano campus (with Prof. Vitiello, member of the EEAB) and The COgITOR coordinator was also invited to give a lecture at the Università degli Studi di Salerno. IIT joined also the 2022 European Researchers' Night. IIT also attended 3 conferences (with 5 talks overall by the PCo), organized afterwards the COgITOR events, by UWE at Bristol https://uncomp.uwe.ac.uk/unconventional-computing-discussions/ https://uncomp.uwe.ac.uk/post-apocalyptic-computing/ and at the 3rd International Conference on Functional Materials and Chemical Engineering hosted in Dubai 9-10 Nov 2022.
- **Empa** joined the Photonics Day 2022, the Empa PhD symposium, it brought up CoGITOR to the photonic community of the Carla Lausanne Campus, and participated in the 'DayLight Academy (DLA) Annual Conference & General Assembly 2022, which was held at Empa.

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Two **events** were also **organized**:

1. COgITOR Workshop on Liquid/Colloid Cybernetic Systems, July 4th, Bristol (UK), jointly organized with UWE Bristol.

2. THE FESTIVAL OF UNCONVENTIONAL COMPUTING OF BRISTOL – in September/October 2022, jointly organized with UWE Bristol.

One event is in the planning stage:

1. Materials Research Society (MRS) Spring Meeting 2024 in Seattle WA, United States; Symposium "Bio Based and Biomimetic Polymers in Soft Robotics", organized by M. Kim (U Arizona), D. J. Mai (Stanford University), N. A. Tegegne (Addis Ababa University), A. Braun (Empa). Tutorial on the topic to be given by Q. Chen (Empa).

The following joint initiatives with other H2020 EU projects were realized:

1. Photo art virtual exhibition

POST-APOCALYPTIC COMPUTING AND TECHNOLOGY

Curator: Irina Petrova (UK)

Advisers: Andrew Adamatzky (UK), Alessandro Chiolerio (Italy), Phil Ayres (Denmark), Konrad Szacilowski (Poland), Anna Nikolaidou (UK)

The exhibition was hosted by the Unconventional Computing Lab (UWE Bristol UK) and FUNGAR and COgITOR H2020 FET OPEN projects.

2. FUNGAR. Fungal Architectures is a new cross-disciplinary research project that seeks to develop a fully integrated structural and computational living substrate using fungal mycelium for the purpose of growing architecture

LINKEDIN INTERVIEW

The project coordinator was also **interviewed on LinkedIn**: Using a fresh format of online LinkedIn interviews, IIT promoted European-funded projects through their coordinator words. An interesting overview of liquid and soft robotics, involving Alessandro Chiolerio in the presentation of COgITOR, which can be found LinkedIn. The coordinator gave also an interview on **the regional TV**, in October 2021 – on TG3 Liguria (reported within the first 6 months of the project on the D.6.3) .

Scientific and non-scientific publications

Scientific publications released:

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1. COgITOR consortium has published the first review paper on liquid neuromorphic materials and devices! The first Author, Dr. Noushin Raeisi Kheirabadi from UWE masterfully drafts a future where devices are unbound from their solid state semiconducting heart, and explore a wide horizon of novel aggregation forms, particularly colloids, gels and liquids in general, offering easily reconfigurable logics and neuromorphic functionalities

2. COgITOR consortium has posted two important pre-prints on ArXiV at the following links: https://arxiv.org/abs/2211.06699 Thanks to the work of Noushin Raeisi Kheirabadi, Alessandro Chiolerio, and Andrew Adamatzky. As a first step towards designing and prototyping colloidal neuromorphic computing systems, Pavlovian reflexes have been observed and confirmed in liquid state colloidal suspensions based on ZnO nanoparticles.

3. Moreover, thanks to the work of Marco Crepaldi, Charanraj Mohan, Erik Garofalo, Andrew Adamatzky, Konrad Szaciłowski, and Alessandro Chiolerio. Notwithstanding relevant advancements in the study of ferrofluids, there was no evidence for their computation capability, before this research. Here, a ferrofluid was exploited to perform electrical analog computing and programming, observing its short and long-term information storage capacity and plasticity. The colloid was capable of classifying digits of an 8x8 pixel dataset, and through Physical Reservoir Computing (PRC) by training a readout layer. Check out this link https://arxiv.org/abs/2211.08152

4. **Papers under review**: 1) “Pavlovian reflex in colloids” by Noushin Raeisi Kheirabadi*, Alessandro Chiolerio and Andrew Adamatzky; 2) “Learning in colloids: Synapse-like ZnO + DMSO colloid”, by Noushin Raeisi Kheirabadi*, Alessandro Chiolerio, Neil Phillips, and Andrew Adamatzky; 3) “Learning phenomena in colloidal polyaniline nanorods” by Erik Garofalo, Neil Phillips, Ermelinda Falletta, Rodrigo José de Oliveira, Alessandro Chiolerio*, and Andrew Adamatzky; 4) “Experimental Demonstration of In-Memory Computing in a Ferrofluid” by Marco Crepaldi, Charanraj Mohan, Erik Garofalo, Andrew Adamatzky, Konrad Szaciłowski, and Alessandro Chiolerio*; 5) “Proposing magnetoimpedance effect for neuromorphic computing” by Loghman Jamilpanah, Alessandro Chiolerio, Marco Crepaldi, Andrew Adamatzky, and Majid Mohseni.

A **non-scientific publication** was also released by PLASMACHEM, namely “Plasmachem Report On The Use Of Titanium Nitride: Photothermal Conversion In Tin-based Nanofluids”

PhD thesis within the COgITOR project:

1. At the end of October 2022, our team member, Erik Garofalo, successfully defended his PhD thesis entitled “Energy harvesting of low-grade waste heat with colloid-based technology” and he was awarded a doctoral degree cum laude by Politecnico di Torino. The work set the basis for the WP4-Energy harvesting of COgITOR and represents a milestone in the colloidal energy harvesting devices domain. The dissertation involved the mentoring of Alessandro Chiolerio, project coordinator, and the contribution of Prof. Carlos Lodeiro Y Espiño and Prof. Sergey Suslov for the evaluation, and of Prof. Andrew Adamatzky, Prof. Marco Masoero and Prof. Yuji Tasaka as members of the examination committee.

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2. In June 2022, Matteo Bevione successfully passed his candidacy exam. Now he is officially a PhD candidate in the Photonics Doctoral Program at EPFL, Lausanne, and supervised by Prof. Giulia Tagliabue, EPFL Laboratory of Nanoscience for Energy Technologies.

MSc thesis within the COgITOR project:

In October 2022, MSc student Ms. Aleksandra Marczyk, AGH University of Science and Technology in Krakow, Poland, Faculty of Materials Science and Ceramics, joined Empa Laboratory for High Performance Ceramics for her 6-month MSc thesis. Supervised by Mrs. Dr. Qing Chen, she worked on the synthesis and analytical assessment of plasmonic nanoparticles and their embedding in polymer films.

RECAP OF ACTIONS AND AUDIENCE REACHED, M18

TYPE OF ACTIONS	M1-M18 SUM
Press release	**3** (IIT Empa CTECH)
Exhibition	**3** (ecomondo 2021-2022- Eu researchers' night)
Flyer	**450** (200 +250 ecomondo 21-22)
Social Media	62 (+13 ecomondo) = **75**
Participation to a Conference	**7** (CARLA camp; 2 in Bristol, DLA, Photonic Day, ICPAM, Dubai ICFMCE)
Participation to a Workshop	**2** (Bioinspired soft robotics + WS on liquid and colloid at Bristol)
Participation to an Event other than a Conference or a Workshop	**2** (Festival unconventional computing + ecological health)
Participation in activities organized jointly with other H2020 projects	**1*** (events organized in Bristol with FUNGAR project)
Project website	**27**
Other	13 +4 ecomondo = **17**

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ESTIMATION AUDIENCE REACHED	M1-M6	M7-M18	M1-M18 SUM
Scientific Community (Higher Education, Research)	3810	2029	5839
Industry	6591	1470	8061
Civil Society	1050	3340	4390
General Public	9,000,000*IIT press coverage 31963	34924 + 24094*(ecomondo2022)	9.090.981
Policy Makers	100	595	695
Media	20	247	267

Investors		315	315
Customers		850	850
Other	1538	400	1938

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MAIN D&C UPDATES & PROGRESS

-Implemented from M19 to M42 -

WEBSITE, LOGO, SOCIAL NETWORKS, VIDEOS, OUTREACH PACKAGE

As stated in the GA, the main focus of this task was on Website, logo, social networks, and outreach package, and all of them were set in place by CTECH and were maintained alive thanks also to partners' contributions.

The following activities were realized from M18 to M42, in the frame of this task, and they are part of the analytic D&C project strategy deployment.

- The **website**, considered as the focal point of external dissemination and internal communication within the consortium, was released as planned at M2, and it is continuously updated, up and running. It has been enriched with a new page focusing on the main project results and progress, whose update reflects both M24 and M36 results achievement. The "news and event" page has been fed with the most relevant information deriving from the partners' activity, new buttons redirecting to the project spreaker account and Youtube account have been added on the Homepage, close to the other social media buttons. From M19 to M42, 27 project news were published to inform about COgITOR main info and updates

- **Social media:** 79 posts on LinkedIn and Twitter/X were published on the social media project accounts and more ones were released by project members tagging the project name. In the months covered in this second reporting period the project Youtube account and Spreaker accounts were also opened to boost the project brand and visibility. 24 other types of activities (i.e. news published) were also released on the corporate websites and monthly newsletters of the partners (mainly CiaoTech) with the same aim.

- The **D&C materials**,implemented at the project beginning, consists of a brochure, a poster, and two versions of roll-up. The materials can be found on the website page "public document" available here https://www.cogitor-project.eu/public-documents/. All of them were updated after every project year, at M12, M24 and M36. They display the project's main features, impact, benefits and objectives, partners' logos, contacts, EC acknowledgment and a specific section devoted to describe the project results achieved in M12, M24 and M36. They can be found on the page mentioned above.

- **Videos**: a project video was realized by EMPA, as stated in the GA, and made accessible on the public documents section of the website. It was uploaded on the Youtube project channel, created for this purpose, whose icon is also present on the project website homepage. A second project video was realized as a teaser to present the COgITOR workshop held in Nizza Monferrato (Italy) on M42.

- As planned on the D&C plan, every six months a **newsletter (NL)** was prepared. Three newsletters were therefore released from M19 ro M42. They were published, released on the social project channels, available on the website, and distributed via CTECH/PNO channels and other partners' too.

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NEWSLETTERS

The following newsletters were released from M19 to M42.

NL 6 June 2024 (M37): This issue of the project newsletter deals with the third year project results, with the most recent technical updates deriving from the activities implemented by the partners involved. It describes how the COgITOR project has reached a level of maturity which is particularly relevant in the field of computing with colloids. Never before the COgITOR project could think about using a liquid to perform any sort of calculus,and after opening such a new route, the entire consortium explored the unprecedented possibilities of building logical gates, systems that can learn and remember, sensors and switches. More info at https://www.cogitor-project.eu/wp-content/uploads/2024/07/Cogitor-Newsletter-06.pdf

NL 5 November 2023 (M30): In this issue the COgiTOR project reported its status in M30, when several notable technical progresses were reached by the joint collaboration of technical partners, IIT, Empa, Plasmachem, UWE, and a new partner that joined the consortium, EPFL. More info here https://www.cogitor-project.eu/wp-content/uploads/2023/12/Cogitor-Newsletter-05-002.pdf

NL 4, May 2023 (M24): The NL 4 was published in May 2023, and it dealt with the second-year project technical updates. A measurement system to assess the capability of commercial colloids to respond as expected in terms of Radio Frequency (RF) to DC stimulation was developed: it allowed us collecting around 10 GB of raw measurements of different colloidal suspensions. These measurements led to the assessment of the capabilities of the materials to memorize information and computing. Based on the the first results, the consortium has started developing a dedicated integrated circuit for measuring the colloids state changes and implement, in an aggressive miniaturized and simplified fashion, the techniques used in the set-up but with very few hardware components to favour integration in a final set-up. To know more on M24 results, the NL is available here It is accessible here, https://www.cogitor-project.eu/wp-content/uploads/2023/05/Cogitor-Newsletter-May-2023.pdf

THE COgITOR PODCAST

A podcast was launched in M42 (November 2024) on Spreaker.com, based on the lectures given during the Nizza Monferrato project workshop. THE COgITOR READINGS first 5 episodes were released and shared on the project website and on social media, more in detail:

1. Dr. Raeisi Kheirabadi introduces us to the most recent exciting discoveries about the fault tolerance of colloid-based computing devices, arising from the amorphous characteristics of the colloidal mixture. These findings highlight the viability of colloid-based computing for future unconventional computing technologies.

2. Dr. Nikolaidou presents living and hybrid unconventional materials, combining sustainable features with active properties, including sensing capabilities. Her exciting research is based on functionalized kombucha hydrogels, that involve living yeasts and bacteria communities populating a soft cellulose network. Future applications encompass smart living buildings and wearable devices.

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3. Dr. Nunes dos Santos introduces us to the marvelous world of self-healing polymers, in other words plastic components that can restore their integrity after being damaged by scratches or cuts, by exploiting their labile chemical bonds that can be easily activated raising their temperature by some degrees. Such materials hold an enormous potential for many future applications, including home devices.

4. Dr. Crepaldi proposes an innovative path towards establishing a digital twin of the colloid electrodynamics based on an artificial neural network. The consequences of such visionary idea is that artificial intelligence could be trained with the raw experimental measurements collected in the last years to create a comprehensive model, that later could be made free to access, making available to the broader community a precious resource.

5. Dr. Antipov discusses the challenges to be faced during the synthesis of commercial colloids, including routes to fabricate high stability, high purity bismuth ferrite nanoparticles featuring the desired oxidation state and crystalline phase. This exciting talk on nanomaterials synthesis for high tech applications brings us directly into the future.

SCIENTIFIC PUBLICATIONS

We provide below an exhaustive list of scientific publications including scientific papers, patents, conference proceedings, as they were implemented/ co-authored by the partners. So far the cumulative impact factor reached by publishing COgITOR activities is 94.7.

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Scientific Papers	1	Alessandro Chiolerio, Erik Garofalo, Neil Phillips, Ermelinda Falletta, Rodrigo de Oliveira, Andrew Adamatzky Learning in colloidal polyaniline nanorods RESULTS IN PHYSICS 58 (2024) 107501 (I.F. 4.4) https://doi.org/ 10.1016/j.rinp.2024.107501
Scientific Papers	2	M. Crepaldi, C. Mohan, E. Garofalo, A. Adamatzky, K. Szaciłowski, A. Chiolerio Experimental Demonstration of In-Memory Computing in a Ferrofluid System ADVANCED MATERIALS 2211406 (2023) (I.F. 27.4) 10.1002/adma.202211406
Scientific Papers	3	Jamilpanah, L., Chiolerio, A., Crepaldi, M. et al. Proposing magnetoimpedance effect for neuromorphic computing. Sci Rep 13, 8635 (2023). https://doi.org/10.1038/s41598-023-35876-0 (I.F. 3.8)
Scientific Papers	4	Matteo Bevione, Alessandro Chiolerio, Giulia Tagliabue Plasmonic Nanofluids: Enhancing Photothermal Gradients toward Liquid Robots ACS Appl. Mater. Interfaces 2023, 15, 43, 50106–50115, https://doi.org/10.1021/acsami.3c06859 (I.F. 8.5)
Scientific Papers	5	Hygro-Dynamic and Conductive Actuator That Restructures and Heals by Water Qing Chen, Tina Künniger, Qun Song, Kai Zhang, Andrei Chumakov, Yusuf Bulut, Constantin Harder, Peter Müller-Buschbaum, Stephan V. Roth, and Artur Braun Adv. Funct. Mater. 2024, 34, 2402924. https://doi.org/10.1002/adfm.202402924 (I.F. 18.5)
Scientific Papers	6	Restructurable materials for soft actuators Qing Chen, Journal of Materials Research 39, 2349–2368 (2024). https://doi.org/10.1557/s43578-024-01423-4 (I.F. 2.7)
Scientific Papers	8	Pavlovian reflex in colloids N Raeisi Kheirabadi, A Chiolerio, A Adamatzky BioNanoScience, 1-9, 2024 (I.F. 3.0)
Scientific Papers	9	Logical circuits in colloids N Roberts, N Raeisi Kheirabadi, MA Tsompanas, A Chiolerio, M Crepaldi, ... Royal Society Open Science 11 (5), 231939 (I.F. 2.9)
Scientific Papers	10	Complexity and nonlinearity of colloid electrical transducers Raphael Fortulan, Noushin Raeisi Kheirabadi, Alessandro Chiolerio, Andrew Adamatzky arXiv preprint arXiv:2410.19757, 2024
Scientific Papers	11	Achieving liquid processors by colloidal suspensions for reservoir computing R Fortulan, NR Kheirabadi, A Chiolerio, A Adamatzky Communications Materials 5 (1), 199, 2024 (I.F. 7.5)
Scientific Papers	12	Boolean Circuits in Colloidal Mixtures of ZnO and Proteinoids R Fortulan, N Raeisi Kheirabadi, P Mougkogiannis, A Chiolerio, et al ACS omega 9 (41), 42127-42136, 2024 (I.F. 3.7)
Scientific Papers	13	Visible light: shaping chemical intelligence in proteinoid–ZnO interfaces P Mougkogiannis, NR Kheirabadi, A Adamatzky New Journal of Chemistry 48 (40), 17650-17669, 2024 (I.F. 2.7)
Scientific Papers	14	Electrical spiking activity of proteinoids-ZnO colloids P Mougkogiannis, NR Kheirabadi, A Chiolerio, A Adamatzky Neuromorphic Computing and Engineering 4 (1), 014007, 2024 (I.F. 5.8)

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Book Chapter	1	A. Chiolerio, M. Crepaldi, D. Torraza, N. Raeisi Kheirabadi, and A. Adamatzky, Post Apocalyptic Computing and Technology: Towards Computing from Natural Colloids and Micro-Fragments in WSPC Book Series in Unconventional Computing book series vol. 5, "Post-Apocalyptic Computing", Chapter 7, 2025, Ed. Andrew Adamatzky, World Scientific ISBN 978-981-12-9713-7 (print) https://doi.org/10.1142/13960

Patent	1	Italian patent application (07/11/2022) n. IT 3384158 (Assignee: Fondazione Istituto Italiano di Tecnologia; Inventors: Alessandro CHIOLERIO, Marco CREPALDI) "Sistema e metodo per la memorizzazione delle informazioni".
Proceedings	1	A. Chiolerio, "Colloid intelligence," Proc. SPIE PC12944, Bioinspiration, Biomimetics, and Bioreplication XIV, PC1294406 (Presented at SPIE Smart Structures + Nondestructive Evaluation: March 26, 2024; Published: 17 May 2024); https://doi.org/10.1117/12.3013018.
Proceedings	2	Implementing Logic Operations in Gold Nanoparticles Colloidal Suspensions R Fortulan, NR Kheirabadi, A Antipov, C Jost, A Chiolerio, A Adamatzky, 13th International Conference on Modern Circuits and Systems Technologies (MOCAST), Sofia, Bulgaria, 2024, pp. 01-04, doi: 10.1109/MOCAST61810.2024.10615444

The following scientific papers are in progress, book chapters, proceedings, and patents in the pipeline, therefore not yet public / filed.

Scientific Papers in Referage / Preparation	1	Adriana Nunes dos Santos, Rodrigo José de Oliveira, Alessandro Chiolerio Plasmonic self-healing materials Completed 1 review round, submitted to RSC Nanoscale Horizons (I.F. 8.0)
Scientific Papers in Referage / Preparation	2	Charanraj Mohan, Marco Crepaldi, Diego Torraza, Andrew Adamatzky, Alessandro Chiolerio Liquid Ferrofluid Synapses for Spike-based Neuromorphic Learning 1st review round, submitted to RSC Materials Horizons (I.F. 12.2)
Scientific Papers in Referage / Preparation	3	Charanraj Mohan, Marco Crepaldi, Alessandro Chiolerio An 180 nm Four-Port Multi-Directional ASIC for Holonomic Features Extraction of Colloidal Systems 1st review round, submitted to IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS I (I.F. 5.2)
Scientific Papers in Referage / Preparation	4	Alessandro Chiolerio, Giuseppe Vitiello, Mohammad Mahdi Dehshibi, Marco Crepaldi, Andrew Adamatzky Room Temperature Colloidal Entanglement in Ferrofluids 1st review round, submitted to Physical Review X: Quantum (I.F. 9.3)
Scientific Papers in Referage / Preparation	5	Alessandro Chiolerio, Marco Pullia, Marco Crepaldi Effects of Ionizing Radiation Bombardment on Ferrofluid Impedance To be submitted to Journal of Physics D: Applied Physics (I.F. 3.1)
Scientific Papers in Referage / Preparation	6	Qing Chen, Roman Furrer, Loghman Jamilpanah, Andrei Chumakov, Yusuf Bulut, Constantin Harder, Peter Müller-Buschbaum, Stephan V. Roth, and Artur Braun Responsive magnetic polymer nanocomposites through thermal-induced structural reorganization Submitted to a ACS Nano (I.F. 15.8)

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Scientific Papers in Referage / Preparation	7	Qing Chen, et al. Soft actuators with actuating and healing capabilities via layer-by-layer assembly To be submitted
Scientific Papers in Referage / Preparation	8	Qing Chen, et al. Small angle neutron study on soft matter actuators To be submitted
Scientific Papers in Referage / Preparation	9	Mapping Boolean Logic with Protein-Based Colloids: A Multi-Electrode Array (MEA) Approach Noushin Raeisi Kheirabadi, Raphael Fortulan, Davin Browner, Alessandro Chiolerio, Andrew Adamatzky
Scientific Papers in Referage / Preparation	10	Matteo Bevione, Narmada Gopal, Giulia Tagliabue Hydrogel-Based Thermoelectrochemical Cells for Efficient Waste Heat Recovery Under Passive Cooling Conditions To be submitted
Scientific Papers in Referage / Preparation	11	Artur Braun, Nikolay Ryzhkov, and Alexey Rulev Soft robot for space exploration exposed to cosmic radiation arriving at Sphinx HFSJG Submitted to International Foundation HFSJG / High Altitude Research Stations Jungfraujoch and Gornergrat Activity Report 2024
Book chapters in Production	1	Alessandro Chiolerio Liquid Spaceships for Advanced Autonomous Exploration Special Issue Book to appear in the Int. Journ. of Unconventional Computing
Record of Invention to be patented (ON HOLD FOR ISSUES)	1	Charanraj Mohan, Marco Crepaldi, Alessandro Chiolerio Multi-Directional ASIC for Holonomic Features Extraction
Record of Invention to be patented	2	Adriana Nunes dos Santos, Alessandro Chiolerio Room Temperature Self-Healing Material

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Scientific talks delivered by COgITOR.

Invited Talks	1	Professor A. Chiolerio Title Intelligence: Attempting to Build a Bridge Between Artificial and Biological Domains 3rd International Conference on Functional Materials & Chemical Engineering Dubai, EAU Date 10th November 2022
Invited Talks	2	Professor A. Chiolerio Title Intelligence: advancements across Artificial and Biological domains Hasard 4, Xocholat Fri-son, Fribourg, CH Date 8th March 2023
Invited Talks	3	Professor A. Chiolerio Title Liquid intelligence: advancements across the synthetic domain 2nd International Conference on Physics and its Applications Los Angeles, USA Date 18th July 2023
Invited Talks	4	Professor A. Chiolerio Title Advances in colloid computers Workshop of Unconventional Computing V-Shed, Bristol, UK Date 5th October 2023

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Invited Talks	5	Professor A. Chiolerio Title Colloid Intelligence ISN2A 2024 – VIth International Caparica Symposium on Nanoparticles / Nanomaterials and Applications Costa do Caparica, Portugal Date 23rd January 2024
Invited Talks	6	Professor A. Chiolerio Title Colloid Intelligence SPIE – Smart Structures + Nondestructive Evaluation Bioinspiration, biomimetics, and bioreplication XIV Hilton Hotel, Long Beach, USA Date 26th March 2024
Invited Talks	7	Professor A. Chiolerio Title Autonomous Liquid Systems for Space Exploration Gagarin Readings Arnolfini, Bristol, UK Date 11th April 2024

Invited Talks	8	Professor A. Chiolerio Title Colloid intelligence IMEM – CNR (seminar) Parma, Italy Date 11th July 2024
Invited Talks	9	Professor A. Chiolerio Title Colloid intelligence IC – ANMBES 2024 Brasov, Romania Date 18th September 2024
Invited Talks	10	Professor A. Chiolerio Title Liquid computing Alternative Computing Architectures Bonn, Germany Date 16th October 2024
Invited Talks	11	Professor A. Chiolerio Title Holonomic computing: early architecture and new developments COgITOR Readings Nizza Monferrato (AT), IT Date 31st October 2024

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Invited Talks	12	Researcher M. Crepaldi Title Computing With Ferrofluids: Observing A Complex Dynamics COgITOR Readings Nizza Monferrato (AT), IT Date 31st October 2024
Invited Talks	13	Researcher A. Nunes dos Santos Title Synthesis and characterization of self-healing clay-polymer composites with enhanced mechanical properties COgITOR Readings Nizza Monferrato (AT), IT Date 31st October 2024
Invited Talks	14	Professor A. Adamatzky Neural networks from thermal proteins Workshop of Unconventional Computing V-Shed, Bristol, UK Date 6th October 2023
Invited Talks	15	Researcher N. Raeisi Kheirabadi Colloid neural networks Workshop of Unconventional Computing V-Shed, Bristol, UK Date 6th October 2023
Invited Talks	16	Professor A. Adamatzky Towards colloid computers Gagarin Readings Arnolfini, Bristol, UK Date 12th April 2024
Invited Talks	17	Researcher N. Raeisi Kheirabadi Neuromorphic architectures in colloids Gagarin Readings Arnolfini, Bristol, UK Date 12th April 2024

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Invited Talks	18	Researcher Raphael Fortulan Towards colloid computers Gagarin Readings Arnolfini, Bristol, UK Date 12th April 2024
Invited Talks	19	Researcher Raphael Fortulan Implementing Logic Operations in Gold Nanoparticles Colloidal Suspensions 13th International Conference on Modern Circuits and Systems Technologies (MOCAST), Sofia, Bulgaria Date June 2024
Invited Talks	20	Researcher N. Raeisi Kheirabadi Boolean functions in Biological colloids COgITOR Readings Nizza Monferrato (AT), IT Date 31st October 2024
Invited Talks	21	Researcher Raphael Fortulan Reservoir computing with biological-based colloids COgITOR Readings Nizza Monferrato (AT), IT Date 31st October 2024
Invited Talks	22	Researcher Qing Chen A hierarchical fabrication strategy for multi-responsive actuators with structural reconfiguration-assisted self-healing ability 87th Annual Meeting of the DPG and DPG Spring Meeting 2024 of the Condensed Matter Section (SKM) Technische Universität Berlin, Germany Date 22nd March 2024
Invited Talks	23	Researcher Qing Chen The Design, Fabrication and Structural Modeling of Biomimetic Soft Materials for Robotic Applications 2024 MRS Spring Meeting & Exhibit Seattle, Washington, U.S.A. Date 23rd April 2024

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Contributed Talks	1	Researcher A. Nunes dos Santos Title Self-healing Materials ISN2A 2024 – VIth International Caparica Symposium on Nanoparticles / Nanomaterials and Applications Costa de Caparica, Portugal Date 23rd January 2024
Contributed Talks	2	Researcher M. Bevione Title Photo-Thermo-Electrochemical Cell for Energy Harvesting MNHMT 2024, 7th ASME International Conference of Micro/Nanoscale Heat and Mass Transfer University of Nottingham, UK Date 7th August 2024
Contributed Talks	3	Researcher Qing Chen Multi-sensing and self-healing skin for robotic applications American Chemical Society, Fall meeting 2023, August 2023 San Francisco, U.S.A. Date 17th August 2023
Contributed Talks	4	Researcher Qing Chen Investigation of strain-induced deformation of polymer thin films with small-angle X-ray scattering (SAXS) as a tool for microstructural study COLLOQUIUM636 "MODULATION OF PHYSICO-CHEMICAL PROCESSES BY ELASTIC STRAIN ENGINEERING" Besançon, France Date 22nd May 2023
Contributed Talks	5	Professor Alessandro Chiolerio Liquid intelligence: advancements across the synthetic domain, The Science of Consciousness TSC-2023 Taormina (ME) Italy Date 23rd May 2023

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Divulgation papers published

Divulgation Papers / Newspapers	1	Alessandro Chiolerio Liquid computing and cybernetics for robotics and computer science Open Access Government 185909 (2024) https://www.openaccessgovernment.org/article/liquid-computing-and-cybernetics-for-robotics-and-computer-science/185909/
Divulgation Papers / Newspapers	2	Federica D'Auria Costruire un computer liquido Wired Italia, 29/12/2023 https://www.wired.it/article/computer-liquido-istituto-italiano-di-tecnologia/
Divulgation Papers / Newspapers	3	Barbara Marcotulli L'Italia all'avanguardia: dell'IIT di Genova arriva il calcolatore a base liquida Maker Faire Rome, 06/02/2024 https://makerfairerome.eu/it/litalia-allavanguardia-dalliit-di-genova-arriva-il-calcolatore-liquido/
Divulgation Papers / Newspapers	4	Francesco Rosso COgITOR: la rivoluzione della robotica morbida svelata a Nizza Monferrato Il Nazionale, 30/10/2024 https://www.ilnazionale.it/2024/10/30/leggi-notizia/argomenti/eventi-e-turismo/articolo/cogitor-la-rivoluzione-della-robotica-morbida-svelata-a-nizza-monferrato-1.html
Divulgation Papers / Newspapers	5	Nemanja Babic Lo studio dei liquidi e la cibernetica - Conferenza del ricercatore Chiolerio La Nuova Provincia, 05/11/2024 in print

MSc thesis within the COgITOR project:

"*Stretching – induced evolution of plasmonic properties of gold nanoparticle – crosslinked polymer thin films*", MEng student Ms. Aleksandra Marczyk, AGH Cracow, Cracow, Poland, carried out at Empa, Dübendorf, Switzerland, supervised by Ms. Dr. Qing Chen, from 01 October 2022 until 31 March 2023.

Open Access Government hosted a general overview article about the main achievements of the COgITOR project written by the PCo; the public reached includes approximately 160.000 Research & Innovation figures, 40.000 Fintech figures, 35.000 local government figures, 15.000 central government figures. Out of those, the company Adjacent Politics declares 100.000 readers are located in Europe.

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NON-SCIENTIFIC PUBLICATIONS

CiaoTech popularized article: in July 2023 (M26) an article/popularized publication was released to spread information about the project main focus and results, in the frame of the stakeholder analysis implemented by CiaoTech, by meticulously mapping the key players in the COgITOR value chain, CiaoTech unleashed a cascade of opportunities while expertly navigating potential barriers, to result in an optimized business and exploitation strategy, innovative problem-solving, heightened stakeholder engagement, and targeted communication. "How can stakeholder analysis maximize the potential of your project and build your market position".

An article was published on **Wired Italia,** that hosted a popularized article about the liquid state computing system developed in IIT by A. Chiolerio and M. Crepaldi, considering the penetration of the international journal owned by Condè Nast group, particularly in the community of technology enthusiasts and geeks. https://www.wired.it/article/computer-liquido-istituto-italiano-di-tecnologia/

Costruire un computer liquido

Succede all'Istituto italiano di tecnologia, dove alcuni ricercatori hanno costruito il primo prototipo di un calcolatore a base liquida. Questo sistema si basa su materiali completamente diversi dal silicio, fondamentale per i microchip che permettono il funzionamento dei computer così come li conosciamo

Press release

A press release about the COgITOR-HERMES vision towards neuromorphic liquid interfaces for enhanced brain regeneration, has been published in May 2023 (M24). It described the exciting Collaboration between COgITOR and HERMES Projects, which Joined Forces for Advancements in Neuromorphic Computing and Regenerative Medicine. Cutting-edge research reveals the potential synergy between neuromorphic colloids and bioartificial neural implants. Magnetic colloids exhibit memristive behavior, positioning them as next-gen neuromorphic devices. The integration of COgITOR's scientific output showcases the possible use of Ferrofluids in HERMES for enhanced brain regeneration. The amorphous nature of Ferrofluids enables self-assembled and self-healing neuromorphic interfaces, fostering electrical connections among neurons. The collaboration promises groundbreaking advancements in computational strategie,s and liquid-state matter utilization. More info can be found on the Press Release reported on the project website.

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EVENTS ATTENDANCE

COgITOR project partners took part in many relevant events in line with the project scope. Below a list of key participation in these events is reported.

Under the task 6.4: Communication activities and public engagement, Communication activities and public engagement have been taken care of by IIT and CTECH, with the support of all participants. All Task 6.4 activities done in the reference period were properly tracked and reported in the EU Reporting platform. The "**Advances in Unconventional Computing**" art&science event was co-organized by the COgITOR project in October 2023, was hosted in-person in Bristol - UK, accompanied by public talks, held in an Art Gallery (The Island). The public talks were further enhanced by art exhibits depicting colloidal cybernetic systems, produced by IIT and Empa, as well as a demonstration of the prototype of liquid in-memory computing realized by IIT in collaboration with UWE, that visitors could see live while computing.

Similarly the **"COgITOR Readings"**, was organized by A. Chiolerio in October 2024, was hosted in hybrid mode in Nizza Monferrato (Asti-IT), accompanied by talks open to public and broadcasted in real-time on Teams, held in a winery cellar (Cantine Bersano) (further info below reported).

Events list:

- COgITOR was showcased at **ECOMONDO 2024 (November 2024),** The Green Technology EXPO event is a significant platform for showcasing and discussing advancements in industrial technologies and sustainable practices, taking place in Italy every year. In this framework, the COgITOR project was featured at the CiaoTech booth and attracted numerous stakeholders during visits interested in knowing more about the innovative cybernetic systems implemented by the project partners
- **In August 2024, EPFL joined the 7th ASME Micro/Nanoscale Heat and Mass Transfer International Conference in Nottingham,** United Kingdom, where it has been discussed new insights on Thermoelectrochemical cells (TEC) for energy harvesting, focusing on the main physical dependencies of the output power on using buffer solution and electrode separation. The discussion was extended to the synergy between photothermal nanomaterial and thermo-electrochemical responses, to create a Photo-Thermoelectrochemical cell (PTEC) extending the operability to sunlight. This system has been developed with European Commission funding from program HORIZON 2020 in the project COgITOR, to demonstrate its potentialities to provide solution for the supply of low-power consumption systems, such as sensors for remote monitoring or harsh environment exploration.
- COgITOR postdoc scientist Dr. Qing Chen from EMPA delivered an invited talk at the **Annual Spring Meeting of the Deutsche Physikalische Gesellschaft in Berlin in the Session Responsive and Adaptive Systems II, March 22, 2024** with title "A hierarchical fabrication strategy for multi-responsive actuators with structural reconfiguration-assisted self-healing ability". https://www.dpg-verhandlungen.de/year/2024/conference/berlin/part/cpp /session/53/contribution/1?lang=en
- in April 2024, in Germany, EMPA joined the **87th Annual Meeting of the DPG and DPG Spring Meeting 2024 of the Condensed Matter Section (SKM)**, with the invited talk Invited Talk at "CPP 53: Responsive and Adaptive Systems II", Invited Talk CPP 53.1 Fri 11:30 H 0107
- Dr. Qing Chen from EMPA also presented at the **Materials Research Society Spring Meeting 2024 in Seattle, United States**, on **April 23rd the** talk "The Design, Fabrication and Structural Modeling of Biomimetic Soft Materials for Robotic Applications" as JMR Distinguished Invited Speaker. The status "JMR Distinguished Invited Speaker" has been awarded to only 11 out of the ~ 3'500 attendees of the MRS Spring Meeting 2024. It is worthwhile to mention – that Empa's Dr. Qing Chen is the only non-

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Professor out of these 11 high profile researchers. For a postdoc, this is a noteworthy award and accomplishment.

- **In February 2024,** COgITOR has been selected to take part to the 1st phase of the Programme – Tech Demo Day on Engineering, promoted by the EIC Venture Building team. IIT joined the exploration workshop with a 5-minute presentation about the electrically programmable liquid state in-memory computer by Chiolerio Alessandro and Marco Crepaldi, featuring its incredible properties of continuum computing, resilience to electrostatic discharge and leakage, and artificial intelligence applications.

- **Ecomondo 2023 with CiaoTec:** The Green Technology EXPO event is a significant platform for showcasing and discussing advancements in industrial technologies and sustainable practices, taking place in Italy every year. The 26th edition marked a long-standing tradition of bringing together innovation and discussions in the field of circular economy, industrial technologies and environmental new processes. In this framework, the COgITOR project was featured at the CiaoTech booth and attracted numerous stakeholders during visits interested in knowing more about the innovative cybernetic systems implemented by the project partners

- **American Chemical Society, Fall meeting 2023, August 2023:** COgITOR postdoc Mrs. Dr. Qing Chen from Empa Switzerland presented the talk "Multi-sensing and self-healing skin for robotic applications" at the American Chemical Society (ACS) Fall Meeting 2023. The ACS Meetings are typically attended by way more than 10'000 participants.

- **Seminar Talk, EMPA, July 2023**: On July 19th, Empa hosted the Prof. Michael Dickey from North Carolina State University, for the invited seminar talk on "Shaping a Sof t Future". It was a captivating encounter with the fascinating world of cutting-edge research and innovation that left everyone in awe!

- EMPA joined a workshop, **EUROMECH COLLOQUIUM636 in Besancon/F,** July 2023, Empa COgITOR postdoc scientist Dr. Qing Chen presented a 30 minute talk on : Investigation of strain-induced deformation of polymer thin films with small-angle X-ray scattering (SAXS) as a tool for microstructural study;

- EMPA joined a workshop "**COLLOQUIUM 636 MODULATION OF PHYSICO-CHEMICAL PROCESSES BY ELASTIC STRAIN ENGINEERING"** 22 May – 24 May 2023, Besançon, France, The European Mechanics Society provides so-called "Colloquia" as a platform for exchanging research with their peer. Empa researcher Dr. Qing Chen, fully funded by Empa's COgITOR budget, has participated in the COLLOQUIUM636 "MODULATION OF PHYSICO-CHEMICAL PROCESSES BY ELASTIC STRAIN ENGINEERING" with a 30 minutes oral presentation with title: "Investigation of strain-induced deformation of polymer thin films with small-angle X-ray scattering (SAXS) as a tool for microstructural study".

- **IIT**: oral presentation in Liquid intelligence: advancements across the synthetic domain, Taormina Italy

- IIT joined a pitch event, **'NEXT'** project proposal submission and presentation, in May 2023. in Hannover (Germany). A new project idea was developed, which is a futuristic potential extension of the COgITOR project. IIT prepared the proposal for this project and submitted to the 'NEXT-Neuromorphic computing' (https://www.volkswagenstiftung.de/en/funding/funding-offer/next-neuromorphic-computing) initiative, of the Volkswagen Foundation during mid-February. This

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funding initiative (funded by the Volkswagen foundation) aims at fostering collaboration and networking between scientists from the diverse research areas engaged in the field of 'Neuromorphic computing' and other recent approaches beyond the mainstream von Neumann architecture.

- COgITOR was selected to take part in the 1st phase of the Programme – Tech Demo Day on Engineering, promoted by the EIC Venture Building team, with IIT

IIT attended the following conferences:

- 3rd International Conference on Functional Materials & Chemical Engineering, Dubai-UAE
- 2nd International Conference on Physics and its Applications , Los Angeles-USA
- ISN2A 2024 – VIth International Caparica Symposium on Nanoparticles / Nanomaterials and Applications, Portugal
- Bioinspiration, biomimetics, and bioreplication XIV – USA
- Title Autonomous Liquid Systems for Space Exploration , Bristol, UK
- IMEM – CNR (seminar) , Parma, Italy
- IC – ANMBES 2024 , Romania
- Alternative Computing Architectures , Bonn, Germany
- ISN2A 2024 – VIth International Caparica Symposium on Nanoparticles / Nanomaterials and Applications , Portugal
- **UWE**: 13th International Conference on Modern Circuits and Systems Technologies (MOCAST) , Bulgaria
- **EPFL**: Micro and Nano- Heat and Mass Transfer, UK
- **EPFL**: Photonic Day EPFL 2024 , Lausanne

Events organization: below we provide a list of the events organized by COgITOR consortium not only to boost the project visibility, but also to engage the scientific community, selected stakeholders and policy makers with the project main technical results and progress.

- **The "COgITOR readings" WORKSHOP, October 31st / November 1st 2024, Nizza Monferrato (Asti, Italy).** A workshop was organized to present all the achievements made in the fields of soft robotics and unconventional computing. Results related to liquid computing devices, amorphous memories, neuromorphic systems, and achievements in material science involving materials for energy harvesting, from thermal gradients to self-healing ones, were presented. The beneficiaries of the project, and scientists from all around the world will be involved, including the United States of America, Australia, and other countries as well. The workshop represented an extremely rich and dense event. Of course, all such information was distributed between the scientific community. But as partners believe in open science practices, iot was also decided to share such information with a broader audience. Therefore, all materials were made available to anybody interested in seeing how the technology of the future could look like.
- **"Advances in Unconventional Computing" workshop October 2023,** the COgITOR project

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orchestrated a workshop titled “Advances in Unconventional Computing,” hosted in-person in Bristol. This collaborative event served as a platform for presenting, discussing, and analyzing breakthroughs in colloid computing within the broader context of novel and emerging computing systems. The diverse spectrum of topics included thermal proteins, fungi, memristors, and enzymatic computers. Through this workshop, participants explored colloidal cybernetics, unveiling its remarkable potential across various scientific and technological domains. The workshop not only highlighted the accomplishments within colloid computing but also fostered an insightful comparison with other unconventional computing paradigms. The workshop’s comprehensive examination of these innovative computing systems underscored their collective significance, paving the way for future advancements and interdisciplinary collaborations in the realm of unconventional computing. The workshop was accompanied by public talks, held in an Art Gallery (The Island, Bristol). The public talks were further enhanced by art exhibits depicting colloidal cybernetic systems, produced by IIT and Empa, as well as a demonstration of the prototype of liquid in-memory computing realized by IIT in collaboration with UWE, that visitors could see while computing.

- Empa Co-PI Artur Braun organized with Minkyu Kim from Univ. of Arizona, Danielle Mai from Stanford University, and Newaye Medhin from Addis Ababa University (Ethiopia) the **Symposium SB11 [Kim 2023] "Bio-based and Biomimetic Polymers in Soft Robotics" at the Materials Research Society Spring Meeting 2024**
- EMPA organized an **International Seminar Talk on "Shaping a Soft Future"**, COgITOR parter Empa hosted Bio Soft Matter Professor Michael F. Dickey from North Carolina State University, July 2023

TYPE OF ACTIONS	M19-M42
Press release	**1**
Exhibition	2 ecomondo
Flyer	500 flyers* ecomondo
Social Media	**79**
Participation to a Conference **EVENTS ORGANIZATIONS**	**4 EMPA** **1 UWE** **2 EFPL** **9 IIT** **3 (ORGANIZED)**
Participation to OTHER TYPE OF EVENT	1 IIT
Participation to PITCH EVENT	**1 IIT**

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Project website	**27**
Other	**24**

ESTIMATION AUDIENCE REACHED*	**M19-M42**
Scientific Community (Higher Education, Research)	106225
Industry	6750
Civil Society	700
General Public	147668
Policy Makers	5495
Media	345
Investors	15
Other	240

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MAIN D&C UPDATES & PROGRESS

-Implemented from M43 to M54 –

WEBSITE, LOGO, SOCIAL NETWORKS, VIDEOS, OUTREACH PACKAGE

As stated in the GA, the main focus of this task was on Website, logo, social networks, and outreach package, and all of them were set in place by CTECH and were maintained alive thanks also to partners' contributions.

The following activities were realized from M43 to M54, in the frame of this task, and they are part of the analytic D&C project strategy deployment.

- The **website**, considered as the focal point of external dissemination and internal communication within the consortium, was released as planned at M2, and it is continuously updated, up and running. Within the last reporting period, 16 project news were published to inform about COgITOR main info and updates

- **Social media:** 36 posts on LinkedIn and Twitter/X were published on the social media project accounts and more ones were released by project members tagging the project name.

- **Videos**: within the final reporting period, 7 videos were released: **COgITOR bonus track video**, **COgITOR: Project Coordinator Alessandro Chiolerio reflects on what we've achieved**, **COgITOR: rethinking computation with liquids**, **From Brazil to COgITOR: Adriana Nunes' Research Journey**, **COgITOR: pressing fluids with light: Diego Torazza on optical memory in liquids**, **COgITOR: Listening to Nature – Afshin Azarpour's Vision for Everyday Intelligent Systems**, **From idea to reality, COgITOR is redefining what computing can be**. All videos are collected on the project website, as well as on the COgITOR YouTube channel.

- **Podcast**: **a podcast was launched in M42 (November 2024) on Spreaker.com, based on the lectures given during the Nizza Monferrato project workshop. THE COgITOR READINGS** episodes were released and shared on the project website and on social media, more in detail:

  - Episode #24: The study of complex systems demands more than just deep expertise, it requires collisions of interdisciplinary minds. That's why, as part of the COgITOR Project, we've created a "bonus track" episode highlighting the power of collaboration across disciplines. Whether you're a researcher, innovator, or policymaker, this is a call to rethink how we approach innovation – together.

  - Episode #23: Dr. Bevione talks about low-grade heat—the kind usually considered too low in energy content to be useful.

  - Episode #22: Prof. Chiolerio presenta un innovativo sistema cibernetico basato su liquidi intelligenti. I sistemi colloidali descritti sono in grado di memorizzare dati, eseguire calcoli, resistere in ambienti estremi e autoripararsi. Integrano sensori, moduli di riconoscimento e generatori termici, aprendo nuove prospettive per la robotica autonoma.

  - Episode #21: Dr. Bevione presenta celle termo-elettrochimiche basate su idrogel per convertire il calore perduto a bassa temperatura in energia elettrica. Questi dispositivi, stampabili in 3D, possono alimentare sensori e strumenti in ambienti difficili, riducendo sprechi energetici.

  - Episode #20: Dr. Pilia proposes to couple together colloidal computing systems and tiny machine learning devices, an extremely promising set of devices featuring very limited energy

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consumptions and costs. His novel idea drafts a low cost device of the future, specifically conceived for edge computing.

- Episode #19: Prof. Konkoli gives an inspiring talk on reservoir computing, crystal clear about many of the nowadays hot topics, such as unsupervised learning, neural networks, and memristors. The idea he is describing brings us to a fascinating upcoming technology of a sensing reservoir computing device.
- Episode #18: Dr. Knez presents some among the most advanced plasma technologies to infiltrate materials and modify their chemistry, creating hybrids out of natural materials or providing new functionalities, such as electronic conductivity, to insulating materials. This groundbreaking innovation enables an infinite amount of practical applications.
- Episode #17: Dr. Ulmann presents the analogue computers, showing how to solve partial differential equations and providing a fascinating paradigm that from vintage technologies moves to the future ones. Analogue computers are capable of solving very complex problems with a quite simple wiring and setup.
- Episode #7A: Neste episódio do Cogitor Readings, Dr. Fortulan apresenta uma pesquisa colaborativa desenvolvida, que explora a computação não convencional utilizando coloides biológicos como reservatórios físicos.
- Episode #16: Prof. Yolles analyses the COgITOR concept in light of the Mindset Agency Theory, a metacybernetic approach where the features of the colloidal autonomous system embody principles of self-regulation, self-organisation, and adaptability to external influences. Insights of this framework will help us in understanding the unique features of living systems when compared to cybernetic systems.
- Episode #15: Prof. Strano discusses about the advancements at the Massachusetts Institute of Technology in the field of colloidal electronics / robotics, where the electronic devices have been suspended in fluid streams to provide higher functionalities. This exciting idea promises to enable sprayable / injectable fully functional autonomous devices, that could explore inaccessible areas.
- Episode #14: Dr. Sen introduces us to the marvelous world of soap films and foams, whose development was done within the European projects “Progeny” and “SOFIA”, bringing our capabilities to the level of controlling the surface chemistry of the top and bottom layers of soap films. Foams are envisaged as photosynthetic reactors to perform sun-activated conversions. The upcoming technology enabled by foams is an artificial leave, capable of converting the carbon dioxide into solar fuels.
- Episode #13: Dr. Krahne discusses how nanophotonic cavities can be made using simple metal-dielectric-metal structures with no lithographic steps needed. Such devices behave as fully tunable Fabry-Perot cavities featuring near zero permittivity materials, and represent an innovative technology for future photonic devices.
- Episode #12: Prof. Suslov gives a review of electromagnetic field equations coupled to fluid flows, whose study has an incredibly broad range of applications, spanning from remote operation to atmospheric and climatic studies. Likewise the typical scale of application can range from nano and micro-devices, up to planetary scales.
- Episode #11: Prof. Descrovi discusses how azocompounds can be exploited as light responsive additives in composite soft materials, whose sensitivity to light polarization provides a means to remotely control their shape. An exciting upcoming technology of light-activated devices is now reality.

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- Episode #10: Prof. Garoli presents research activity on iontronic devices, an extremely promising field that will enable processing information with ionic channels, instead of electronic ones. By leveraging on the abundance of ions he envisages multi-binary parallel logics to enable future technology conceived for neuromorphic computing and biosensing.
- Episode #8: Dr. Tarabella discusses several examples of recent research performed with organic semiconductors and devices, developed with novel processing technologies and materials, featuring unprecedented sensing capabilities. Findings enable brand new devices based on soft matter of great availability and sustainability.
- Episode #7: Dr. Fortulan presents amazing findings about the advanced electronic properties of both synthetic and natural colloids, in particular memfractance and reservoir computing (RC) tasks. He shows that RC is exceptionally executed by modified egg white proteins, providing an abundant source substrate, and featuring excellent figures of merit, compared with conventional artificial neural networks. The future technology enabled is computing with natural colloids.
- Episode #6: Prof. Chiolerio discusses how the architecture design of a holonomic cybernetic system has changed and evolved to take into account recent advancements in the pioneering research on colloidal substrates. Liquid state machines, neuromorphic systems, learning and plasticity, multi-particle phase correlation are addressed. Findings enable an upcoming technology based on holonomic liquid devices for massively parallel computation.

- **Newsletter**: **the 8th issue of the project newsletter**, released in December 2025, provides an overview of the latest project updates.
- **Scientific publications**: 6 scientific publication were published in the frame of the third reporting period:

Type of publication	Title	Authors	Year
Article in Journal	Robust, self-healing polyurea/TPU elastomers	Adriana Nunes dos Santos, Matia Pesce, Luca Ceseracciu, and Alessandro Chiolerio	2025
Article in Journal	Hydrogel-based thermoelectrochemical cells for waste heat recovery under passive cooling conditions	M. Bevione, N. Gopal, G. Tagliabue	2025
Article in Journal	Reconfigurable soft actuators constructed via layer-by-layer assembly	Chen, Q., Jamilpanah, L., Künniger, T., Furrer, R., Song, Q., Zhang, K., … Braun, A.	2025
PhD public defense	Harnessing Waste Heat and Light with ThermoElectrochemical Cells	Matteo Bevione	2026
Article in Journal	An 180 nm Four-Port Multi-Directional ASIC for Holonomic Features Extraction of Colloidal Systems	Charanraj Mohan; Marco Crepaldi; Alessandro Chiolerio	2026
Article in Journal	Observation of phase correlations in ferrofluids	Alessandro Chiolerio, Giuseppe Vitiello, Mohammad Mahdi Dehshibi, Marco Crepaldi, Diego Torazza & Andrew Adamatzky	2026

- **Popularized publication:** 1 popularized publication was realized: COgiTOR_Pioneering liquid cyberneting computing.
- **Events attended**: 4 conferences (including EFF2025; Presentation of a work regarding an "Unconventional" Turing Machine to explain the dynamics of the colloids studied in COgITOR; European AI for Fundamental Physics Conference; Quantum Information &

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Probability Conference); 1 exhibition (Ecomondo 2025); 1 workshop (Final Workshop of the COgITOR project) were attended and/or organized.

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