INSIDE magazine

December 2024 — Issue 08

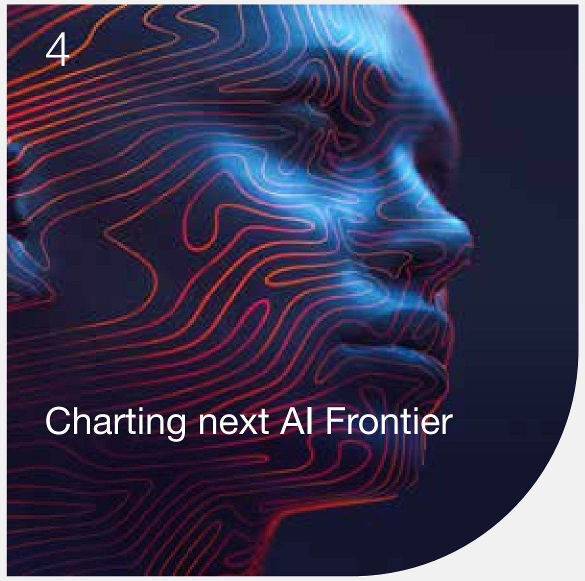
In this issue:

- **Charting next AI Frontier**
- **Strengthening Europe's Competitiveness**
- **HAL4SDV : Advancing Europe's Leadership in SDV and Future Mobility**

INSIDE
Industry Association

In this issue

December 2024 —— Issue 08



Dear reader,

In a world defined by rapid technological advancements and shifting global dynamics, Europe finds itself at the crossroads of opportunity and responsibility. In this dilemma, Europe's competitive edge lies in its ability to innovate while remaining faithful to its values of collaboration, sustainability, and inclusivity. This edition of INSIDE Magazine underscores how various projects in our community are contributing to pave the way for a resilient and forward-thinking Europe.

From the cutting-edge demonstrations in smart manufacturing and industry automation at the ICE Laboratory, with features such as reconfigurable production lines, robotic assembly, virtual reality, quality control systems, etc. To the Arrowhead FPVN , which empower digital transformation and automation ecosystem using local clouds, semantic modeling, interoperability, service oriented architectures, etc. These integrated solutions bridge research and industrial applications, fostering collaborations and preparing for Industry 5.0.

Alongside these efforts, the strategic importance of initiatives like OpenContinuum and CEI-Sphere lies in their focus on the edge-to-cloud continuum, coordinating 50 projects and three large pilots to strengthen Europe's digital autonomy and ensure robust, scalable solutions for the future.

Similarly, HAL4SDV supports Europe's automotive leadership while addressing sustainability and competitiveness, with the cutting-edge consolidating trend of software-defined vehicle, creating a platform for seamless hardware-software integration in the automotive industry and paving the way to the future of the European Digital Vehicle.

These projects are not merely technological endeavors: they embody the vision of a united and collaborative Europe capable of addressing global challenges with innovation and advanced solutions.

AI emerges as a recurring theme, with insights into its evolution and potential to reshape industries. However, the articles remind us that innovation must be grounded in ethical considerations and robust frameworks. A specific article explores AI's transformative potential and its challenges in scaling and effectiveness, highlighting its dependency on high-quality data, the prohibitive costs for training and the limitations of current technology. It also envision a future where AI integrates with bio-inspired systems and quantum computing, calling for multidisciplinary collaboration to navigate this evolving landscape.

This edition also reflects on the strategic recommendations from Mario Draghi's report, which provides a framework for Europe's economic and geopolitical challenges, focusing on innovation, sustainability, and industrial growth. Recommendations include establishing a European "DARPA" to enhance tech leadership, safeguard our digital autonomy and foster breakthroughs in critical technologies.

As you explore these narratives within this issue, I invite you to draw inspiration and reflect on how Europe can continue to lead in a competitive world by leveraging its values, its strengths, its competitiveness, investing in people, in innovation, in collaboration and embracing a shared vision of progress.

Paolo Azzoni

Secretary General

Technology Frontiers INSIDE Magazine 8

Technology Frontiers

Charting Next AI Frontier

From Technological Limits to Paradigm Shifts

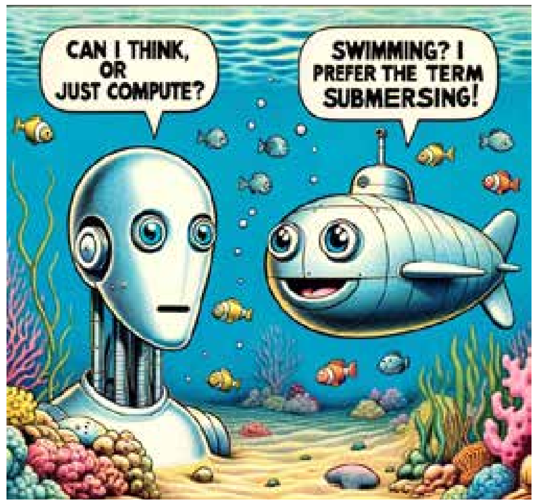
Paolo Azzoni

When we think of AI we tend, by our nature, to ask how closely artificial intelligence can duplicate human intelligence, but maybe this is not the best comparison, at least not always. It is like comparing a submarine with a dolphin: they can both swim, but is a submarine really swimming? I discovered there is a philosophical discussion about whether a submarine can really swim …

But what is the point? Like Edsger Dijkstra said, probably the comparison is not the right one and it also not interesting. I asked DALL-E to draw for me a comic vignette of Djikstra's famous postulation … it was funny (asking an AI to satirise itself) and the result is remarkable. Nevertheless, using human intelligence as a term of comparison to evaluate the progress of AI is … human, understandable and sometimes also reasonable.

It is also useful because when we do the comparison, we consider specific capacities of our brain, and we try to verify whether AI is capable of mimicking them and how well it does. So, indirectly we understand better which problems AI can solve and where we could adopt this technology. Even more: AI can evolve in so many directions and it would be wrong to focus entirely on human-like directions. For example, science fiction visions of AI have been largely off because we have adopted computers most frequently to do common tasks humans can't do well, not exactly the romantic view of AI mimicking feelings, desires and thoughts. Machines are incredibly good at doing boring tasks, from sorting lists to extremely complex and massive calculations … and in doing this they mimic humans while providing enormously better performances. So, is everything a machine is doing AI? There is a wide debate on this, probably never ending … I don't want to enter into it. However, to try to answer the questions I want to address in this article we need to understand first what AI is. I am not interested in a formal definition but in the practical meaning: AI is algorithms that simulate human intelligence, whether are they implemented in hardware or software or both, and it is widely based on statistics and probability, which are indispensable for example in pattern recognition, decision-making and predictive modelling. However, AI is a multidisciplinary field that integrates logic, cognitive theories, engineering principles and hardware innovations.

But at the very end AI is mathematics, whether silicon mathematics or software algorithms, it is mathematics … no more than that. It has no common sense (see my article in issue 4), no consciousness, no feelings, no desires, no will … for the moment.



The question of whether a computer can think is no more interesting than the question of whether a submarine can swim.

Edsger Dijkstra

And here come the questions I mentioned: what are the limits of current AI technologies? How much further we can push them? Is there any impassable barrier to the current semiconductor-based AI?

The three AI pillars

For over fifty years, AI has experienced several hypes but, despite these moments of enthusiasm, many efforts to advance AI have faltered due to impractical ideas and mainly technological limitations, leading to periods of disinterest known as "AI winters". However, around 2010, AI experienced a revival with the emergence of Deep Learning, a discipline that leveraged multi-layered neural networks to achieve significant breakthroughs and reignite optimism about AI's potential. This revival is based on three pillars:

- **Algorithms:** recent algorithmic advances have introduced innovative applications and established a new approach to statistical computing, distinct from traditional "expert systems" that rely on algorithms and software engineering for precise calculations. Consider for example the success of neural architectures across various domains (e.g. computer vision and natural language processing).
- **Data:** at the core of neural architectures as a method of statistical computing is the data-driven approach. Unlike traditional software that relies on explicitly programmed rules, this approach defines tasks by training the neural network on example of inputs and outputs (also known as "Software 2.0"). By learning from these examples, the network adjusts its weights, enabling it to approximate solutions and generate outputs for new, unseen inputs. However, the effectiveness of these approximations relies heavily on the availability of a sufficiently large dataset, as neural networks require extensive training data to perform accurately and reliably. The availability of huge amount of data, stored in structured and semi-structured datasets, is providing today more material for the training and opens up new possibilities in terms of applications (e.g. automotive).
- **Computing:** the ability to experiment with new algorithms on large datasets depends on the access to powerful computing infrastructure, including high-performance silicon chips, memory systems and interconnects. Without sufficient computational resources to handle the demands of training algorithms on vast datasets or running inferences on new data, it would be impossible to validate whether a neural architecture performs effectively.

The three pillars represent the main enablers of modern AI.

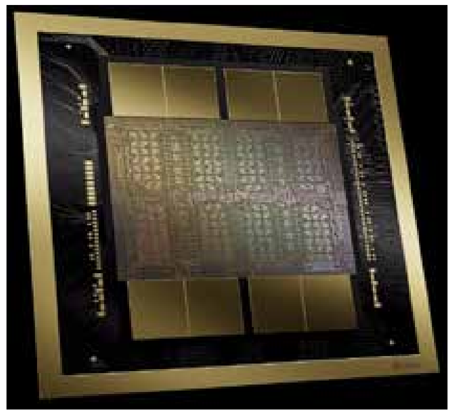
Brain or brawn?

Considering the computing resources currently required by GPT4 and on the assumption that the largest AI models continue to grow at their current pace until 2030, the computing resources will have to grow by three orders of magnitude. Scaling at this pace is possible according to Moore's law only if we don't consider the transistor price; in that case, the transistor density of the most advanced computer hardware continues to grow exponentially. Considering the cost-effectiveness, transistor density reached stagnation over a decade ago.

But scaling AI means something new, certainly including the number of computing units but also their speed, the utilisation rate and the time requested to training. Which means not just pure calculations, but also high-speed memory access and communication between CPUs: it is a delicate equilibrium between the number of CPUs/GPUs and the time spent making calls to the memory. How training time will evolve is difficult to predict: the largest LLMs currently require months, and this is already an unsustainable business model.

The solution? Brute force: smaller transistors, more transistors in chips, more cores, more operations per seconds, etc. For example, the top-of-the-line Nvidia data centre GPUs Blackwell B200 GPU features a total of 208 Billion transistors.

But there are inherent physical limits to transistor miniaturisation. First, there is thermodynamics: the smaller the transistor becomes, the lower will be the energy required to switch on and off, and this energy is so low that confusion arises with the random movements of molecules (heat), causing the transistor to randomly switch. The solution is new materials beyond silicon: a group of Chinese scientists has claimed to reach 0.34 nm transistor gate[1] (as a term of comparison, TSMC 3nm process has actually 16-18 nm gates). Second: manufacturing process limitations. The light used in photolithography cannot resolve features smaller than about half the frequency of the light itself (i.e. tens of nanometres). Some solutions adopt higher-frequency radiation like x-rays, but also in this case the time horizon before reaching the limit is 3-5 years and the cost is prohibitive.



Nvidia GPUs Blackwell B200 GPU

A completely different approach is to redesign chips. An option consists in the manufacture of 3D chips, where transistors are stacked vertically. This approach was already used in 3D memories and, currently, the number of layers can be significantly high (Samsung estimates 1000 layers by 2030[2]), with a transistor density scaling linearly without reducing transistor dimensions.

Another option is represented by ASICs, special-purpose chips designed to execute only a specific type of computation for a specific application. The GPU manufactured by Nvidia, Google, Amazon, Tesla, etc. fall in this category, which provides more computation per second with the same number of transistors of a general-purpose CPU/GPU.

A third, more radical, option is to replace the transistor as a switch with something else. Optical computing for example relies on light, that is photons which are about 20 times faster than electrons: the University of Arizona has developed an optical device capable of switching a million times faster than transistors. The limitation is the density of this optical device that is higher than the one achievable with transistors[3]. An alternative can be found in memristors, basically a resistor with memory, retaining resistance changes, and which could scale down to 1 nm.

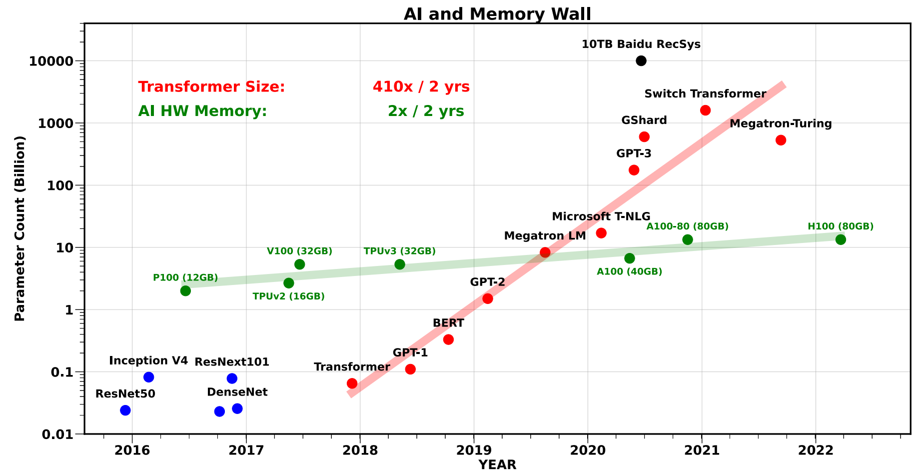
With these options it is possible to go beyond the Moore's law, but then there is the problem of the "memory wall". Indeed, brute force is not enough to scale up, because the time for training represents an obstacle, both technological and financial. A significant portion of time during training is spent in accessing the memory (typically DRAM and VRAM) and the memory bandwidth does not scale at the required pace[4]. Nvidia Blackwell B200 GPU is equipped with up to 192 GB of HBM3e memory. Just to understand the dimensions of the problem, it has been estimated that a model that today requires six months of training, using 60% more the GPU, requires about 2.5 months just for transferring data to and from the memory. Also, memory bandwidth depends on clock speed, which has not increased significantly in the last decade. Luckily, we can work on the width of the memory bus, allowing faster data streams: with 3D technologies like the High Bandwidth Memory (HBM) the limiting factor is represented by the number of layers that can be stacked, which impacts on heat, generating thermal noise, which can alter and degrade the data stored in memory … Blackwell B200 GPU offers 8 TB/s of memory bandwidth across an 8192-bit bus interface.

And finally, there is the problem of energy efficiency, which would require an entire article in itself: it's a very well-known issue that current AI hardware consumes vast amounts of energy, especially for large-scale models and real-time applications. This energy inefficiency is becoming a major barrier to scaling AI systems and achieving sustainable operations: by way of comparison, the human brain is very energy-efficient being estimated to consume around 20 Watts while even executing extremely complex "computations"[5].

Software limitations

In the lower layers of the software stack, modern AI applications are predominantly built around a single type of computational operation: matrix multiplication. Convolutional neural networks (CNNs) reduce their operations to sets of matrix multiplications, while transformer models rely on matrix multiplication as part of their multi-head attention mechanisms. Optimising hardware for matrix multiplication is significantly complex because it involves challenges in computation, data access, scheduling and communication.

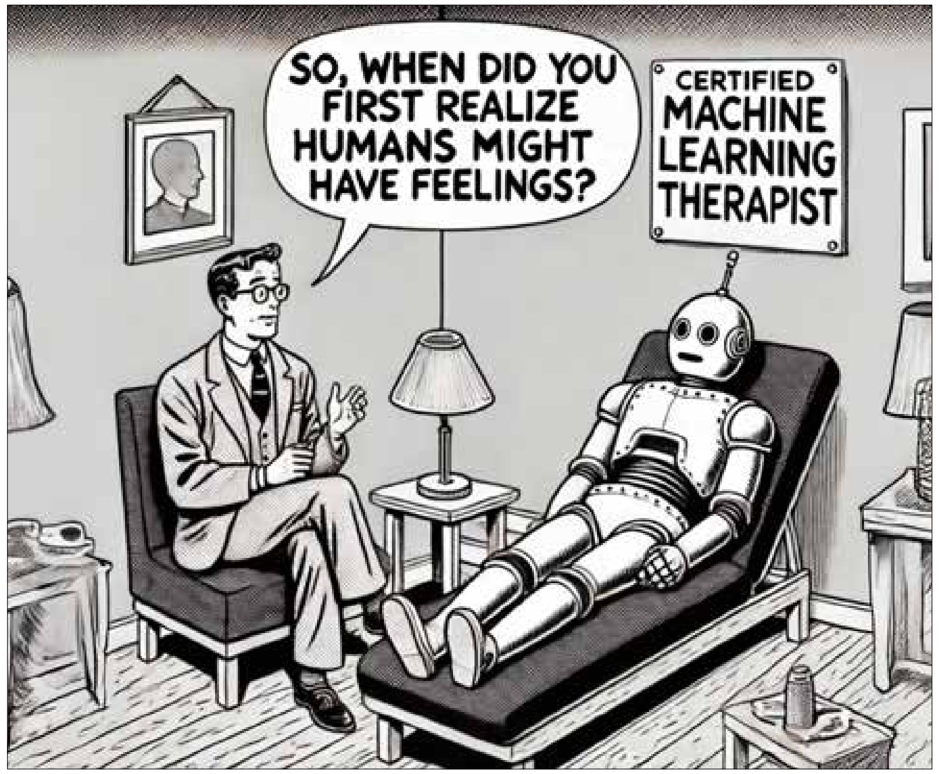
Moving at the algorithms level, bias represents a great limitation. Algorithms are basically sets of rules or instructions that a computer follows to perform specific tasks. These instructions may be created by human programmers or generated through other processes, e.g. AI itself. However, the reliability of algorithms depends on their integrity and fairness; flawed or biased



The evolution of the number of parameters of SOTA models over the years, along with the AI accelerator memory capacity (green dots).[4]

algorithms can lead to undesirable outcomes. Such biases often stem from incomplete or biased design decisions by developers, who may inadvertently prioritise certain criteria over others, but could also be generated by a poor model or training of the AI used to generate them. Algorithmic bias is especially prevalent in large platforms like search engines and social media. For example, in 2017, Facebook deployed an algorithm to remove hate speech: it was later revealed that the algorithm allowed hate speech targeting specific groups, such as black youth, while blocking similar content directed at white men. This occurred because the algorithm focused on broad categories like "whites" and "blacks" rather than addressing specific subgroups, leading to unintended gaps in its enforcement.

At a higher level, another limitation is represented by the AI models and by the algorithms used to train them. Huge LLMs cannot scale further, and all the AI key players envision a future where LLMs have to be tailored to the problems they are intended to solve (task-specific training). Small models like Alpaca and Vicuna, with an appropriate fine tuning with a specific dataset, almost match the performance of a larger LLM trained



DALL-E interpretation of AI bias :)

> Efficient hardware is a must, but unless it offers clear physical superiority, efficiency alone is unlikely to provide a competitive edge. Success lies in the ability to meet clients' computational needs effectively and seamlessly, minimising their effort to build on hardware.

from scratch. Trade-offs consisting of an LLM trained with a small general-purpose dataset of human text and with a specific dataset of human-chatbot interactions have been demonstrated to be significantly less hungry in terms of resources and as performant as LLMs trained with huge datasets.

In terms of model there is data: AI learns only from the data with which it is provided, meaning performance and accuracy are directly tied to the quality and reliability of this input. If the data is flawed or biased, AI's outcomes will likely reflect those issues, undermining its intelligence and effectiveness. One of the major challenges in implementing AI is ensuring the consistency and quality of data. Businesses aiming to scale AI solutions often struggle with fragmented, inconsistent and poor-quality data. To address this, organisations must establish a clear and well-structured strategy for collecting and preparing data from the outset, ensuring it meets the requirements of the AI systems for optimal performance.

At a more abstract level, also adaptability, ethics, morality and common sense have to be considered: AI is absolutely limited from these perspectives. Computers lack emotions and, while they outperform humans in specific tasks in terms of efficiency, they cannot replace the emotional and ethical bonds that form the foundation of human relationships, because ethics and morality are integral to human nature, and are challenging to replicate in AI. As AI rapidly advances across industries, concerns grow that its unchecked development could eventually threaten even humanity's existence. Moreover, AI relies entirely on pre-programmed data and past experiences, limiting its adaptability compared to human intelligence. It can perform repetitive tasks efficiently, but any adjustments require reprogramming. Common sense also plays a part and is an enabler of adaptability, a crucial element in humans and currently completely missing in AI: common sense represents a key instrument that humans use to solve every kind of problem and its lack in AI is one of the most limiting factors, affecting also very specialised applications.

The technology stack

Hyperscalers and large tech companies design their own chips to clearly achieve and preserve a technical and commercial advantage over potential competitors but, counterintuitively, this strategy doesn't consist only of building chips.

The strategy is primarily focused on guaranteeing complete control of the full technology stack, covering both hardware and software.

When we look at the pure computational power of AI oriented chips – CPUs, GPUs, TPUs, ASICs, etc. – that is at their pure capability to process bits, they do not differ significantly at the end. Seen from outside they are just muscles, horsepower, elephant force … conceived to elaborate a huge amount of numbers in the shortest possible time.

The differentiating element is represented by the capability to control the entire stack, starting obviously from the chip itself, and including firmware, virtualisation layers, drivers, operating systems, middleware, application oriented, libraries, etc. and all the related engineering tools, including development toolchains, modelling environments, test and debug frameworks, IDEs, deployment and commissioning frameworks, etc., which are starting to be strengthened by the integration of AI itself.

This approach, called "verticalization", is the strategy at the base of Nvidia success, composed of the best hardware solutions and the best software stack, that is the best system, the best integrated technology stack.

Indeed, a crucial aspect to achieve successful verticalization is system co-engineering: co-design and co-optimisation allow more integrated, efficient, adaptable and high-performing solutions to be identified. "System thinking" requires a top-down approach, while traditionally designers and developers, pushed by the transistor-driven technology advancements, typically focus on a bottom-up approach which, lacking the visibility of the system level, limits the opportunity to fully exploit HW/SW capabilities and satisfy the final user requirements. Indeed, the system-level approach starts from application requirements to identify potential solutions: it is a more natural approach in which the application defines the characteristics of future hardware, not software that is forcibly adapted to run on existing hardware to satisfy the application needs.

"System thinking" extends even beyond these concepts: the development of future computing system architectures involves an iterative co-design loop, starting with understanding target application

requirements, workloads and algorithms. This iterative methodology spans all system layers, integrating innovations in hardware, software and algorithms, and relies on performance feedback to refine designs. Advanced modelling and prototyping are used to address system scaling challenges and validate new technologies, from post-Moore computing paradigms to system-based advancements. Success depends on a multidisciplinary team leveraging expertise in diverse areas to drive impactful and scalable solutions.

Agentic AI

Agentic AI is a very good example of such a system-oriented effort to meet application needs. Agentic AI refers to advanced AI systems that can autonomously plan, make decisions and execute tasks without the need for continuous human input. These systems go beyond traditional rule-based AI or static generative models by incorporating dynamic adaptability, learning from feedback and handling complex workflows independently. Key to their operation is their ability to process real-time data, set and pursue goals, and adjust actions based on evolving conditions.

Agentic AI benefits from cutting-edge hardware such as GPUs and TPUs for high-performance computation, enabling real-time data processing and decision-making, and tightly coupled with software solutions for machine learning (ML) and deep learning (DL), leveraging neural networks to adapt and optimise based on data, and natural language processing (NLP) for interaction, computer vision for perception, and reinforcement learning to improve decision-making over time.

Application areas include autonomous vehicles, which rely on real-time navigation, continuous learning and decision-making, and healthcare, where agents assist in diagnostics and treatment recommendations, extending to a wider range of domains such as cybersecurity and finance, where agentic AI systems autonomously monitor, analyse and act on anomalies or market trends.

In terms of limitations, their "independence" from humans and their implementation raises challenges in ethics, transparency and security, requiring robust governance and oversight to ensure their safe and effective use.

Emerging alternatives? Organoids, neuromorphic, …

Semiconductor-based AI will be "the solution" for a long time because it represents a very good compromise (cost, efficiency, performance, etc.) for a very wide range of applications. But it will very soon face limitations, and several obstacles could hinder its evolution.

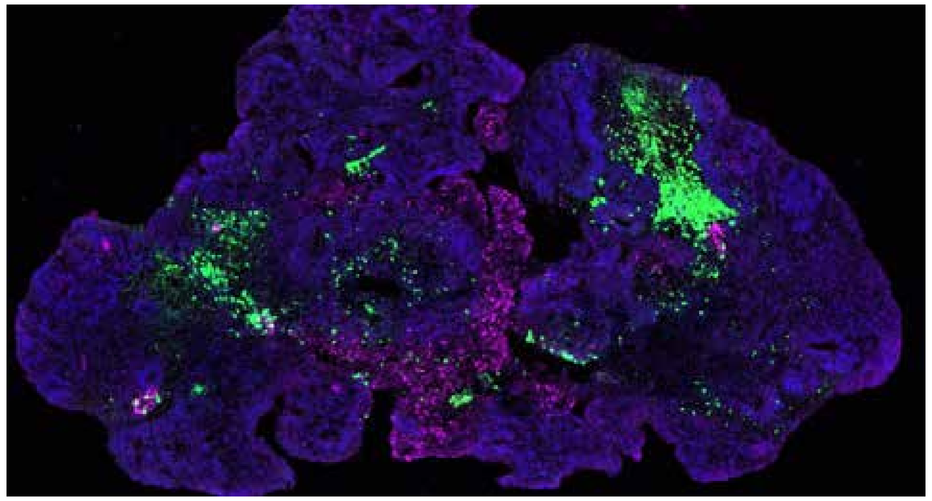
We need alternatives, specifically in the perspective of finding solutions that satisfy the necessity of specific applications.

An option is represented by cerebral organoids, a cutting-edge tool in neuroscience and biotechnology, advancing our understanding of brain function and development. A cerebral organoid is a three-dimensional structure grown in a lab that mimics certain features of the human brain. Organoids are created from pluripotent stem cells, which have the ability to differentiate into various types of cells, including neurons. When cultured under specific conditions, these cells self-organise into layered structures that resemble the developing human brain, including regions like the cerebral cortex. They can replicate early stages of human brain development, making them valuable for studying neural formation, genetic disorders and developmental processes. Currently they are widely used to investigate neurological diseases such as Alzheimer's, autism and microcephaly, providing insights into pathologies that are difficult to study in living humans.

A long-term goal is to merge AI with biological neural networks. This would involve creating AI systems that can adapt and learn based on feedback from organoids, potentially enabling a more organic form of machine learning. The hybrid system could offer a more bio-realistic approach to cognitive processing, pushing AI capabilities beyond traditional digital architectures [10].

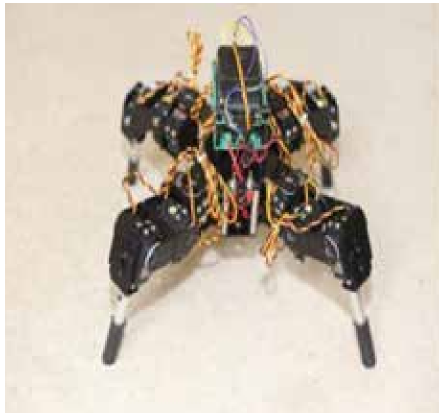
But organoids are already a reality:

- You can directly program them with the online Neuroplatform by FinalSpark[6] thereby allowing programming and remote interaction with cerebral organoids.
- Human organoids have been also implanted in mouse brains[7] specifically in the cortex, where they have shown



A section of a brain organoid after three months of culture, evidencing with colors the distinct types of cells and the organoid's structural complexity (Arlotta laboratory).

A robot toy with an artificial brain and a neural chip (Tianjin University).



A spiderlike robot that (Muotri Lab/UC San Diego).

- functional integration. These organoids were able to respond to external light stimuli in a similar way to the surrounding mouse tissue[8], demonstrating the potential for organoid-based solutions to restore or enhance brain functions. The implanted organoids also benefited from vascularization by the host's blood vessels, supporting their survival and function.
- Cortical organoids have been integrated into robots[9,10,11] (biochip system), acting as a "middle layer" in a hybrid computing system, interacting with external stimuli and helping guide robotic tasks such as navigation and object manipulation. This collaboration between AI, organoid intelligence and robotics aims to create more energy-efficient systems while offering insights into neural function.

Estimating the limitations of organoids is premature but, certainly, although they lack consciousness or full brain functionality, their increasing complexity raises ethical questions about their use in research and industry.

Another alternative to digital AI inspired by biology is represented by analog solutions, such as neuromorphic computing, a computing paradigm inspired by the structure and function of biological neural networks (like the human brain), mimicking the brain's ability to process information efficiently, adaptively and with low power consumption. Neuromorphic computing is a mature technology, which relies on hardware architectures designed to emulate neurons and synapses, such as spiking neural networks (SNNs), which process information through event-driven communication rather than continuous data streams. Neuromorphic computing aims to overcome the limitations of conventional AI by enabling real-time, low-energy processing, particularly for edge devices like sensors, autonomous robots and wearables (as in Intel Loihi[12] and IBM TrueNorth[13]). Neuromorphic systems are not intended to entirely replace conventional AI but to be complementary in specific tasks like sensory processing, pattern recognition and real-time decision-making.

Although more mature than organoids, neuromorphic HW and SW ecosystems are still in their infancy, with limited tools and frameworks for large-scale application development. Indeed, programming these systems requires a shift from traditional computing models, which presents a steep learning curve for developers. And there are performance limitations: while they excel in low-power, real-time processing, neuromorphic systems may struggle to handle large-scale, data-intensive tasks where conventional AI systems outperform them.

Intel Loihi 2

Quantum computing

From a long-term – and widely speculative – perspective, quantum computing has the potential to revolutionise AI by leveraging its unique capabilities to solve problems that are challenging or even intractable for classical computers, leveraging the unique properties of quantum mechanics for learning and prediction.

Quantum computing can accelerate the training of AI models by efficiently handling large datasets and performing operations like matrix multiplications, which are central to AI algorithms. Quantum parallelism allows the exploration of multiple possibilities simultaneously, potentially reducing the time required to optimise neural networks. But it also enhances data processing, effectively processing and analysing high-dimensional data, which is useful for example in NL processing and image recognition.

Many AI tasks, such as machine learning model training, involve optimisation problems that require the best solution to be found from a vast domain. Quantum algorithms, such as the Quantum Approximate Optimisation Algorithm (QAOA), can potentially solve these problems faster by leveraging quantum superposition and entanglement.

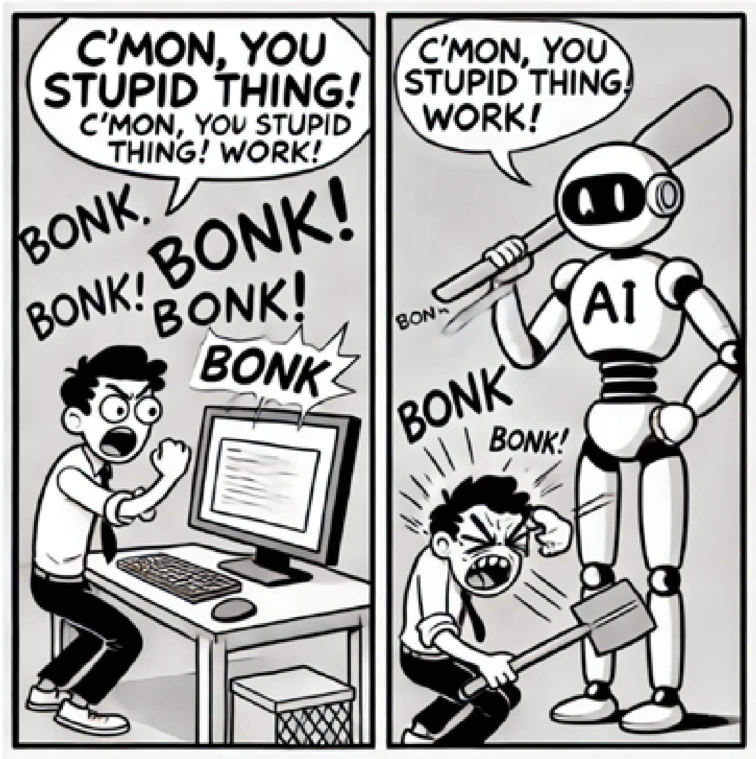
Moreover, quantum techniques, such as Quantum Principal Component Analysis (qPCA), can help identify the most relevant features in a dataset, improving the performance and efficiency of AI models. This is crucial for reducing computational complexity in machine learning, which can be implemented with novel machine learning algorithms, such as Quantum Support Vector Machines (QSVMs) and Quantum Neural Networks. These solutions can outperform their classical counterparts in specific tasks.

Unfortunately, current quantum computers are in the early stages, with limited qubit counts and significant error rates, restricting their scalability and reliability. Algorithms for AI are still in the research phase, and practical implementations are very limited and trying to leverage the possibility to bridge quantum and classical computing for hybrid AI solutions remains a complex challenge. Not to mention the computation model, development tools and developers' expertise that are far from being available.

Quantum solutions are just a step away from science fiction … for the moment.

Going SciFi

Entering the domain of science fiction, Artificial General Intelligence (AGI) is the theoretical stage where an artificial intelligence system can perform any intellectual task a human can. This includes reasoning, understanding, learning from experience, and adapting to new, unforeseen challenges across diverse contexts: AGI would possess generalised intelligence, allowing it to apply knowledge and skills across domains without requiring task-



Apart for the shovel on the right, DALL-E seems to know already what its future could be …

specific programming. For example, while today's AI can excel in games like chess or Go, AGI would not only master these games but also translate the strategic thinking involved into solving real-world problems like optimising supply chains or conducting scientific research. It would possess the flexibility and creative reasoning of a human mind.

And going a step even further, Artificial Superintelligence (ASI) represents the hypothetical leap beyond AGI, where machines surpass human intelligence in all areas, including creativity, problem-solving, emotional intelligence and even decision-making. This level of intelligence would allow an ASI system to solve problems with unparalleled efficiency, such as devising cures for complex diseases, mitigating climate change, or revolutionising technology. Its ability to recursively improve itself could lead to an "intelligence explosion", where each improvement accelerates the pace of subsequent advancements, quickly outpacing human control and comprehension. For instance, an ASI system tasked with advancing medical research could read and synthesise all existing scientific literature in mere hours and propose revolutionary treatments, potentially solving centuries-old problems overnight. Its speed and scope would render it capable of addressing global challenges that currently seem insurmountable.

The development of AGI and ASI raises profound questions about control, safety and morality; indeed ensuring that superintelligent systems act in accordance with human values is a critical challenge. Misaligned goals could lead to catastrophic outcomes, such as an ASI solving a problem in ways that conflict with human survival (e.g., eliminating cancer by eradicating all humans). Moreover, as ASI surpasses human capabilities, questions arise about how much decision-making should be delegated to machines and whether humanity would retain control over its own future. Everyone can also imagine the effects if the concentration of ASI in the hands of a few … but luckily it is still science fiction … or not?

Well, today's AI systems are narrow, designed for specific tasks such as language processing (e.g., ChatGPT) or image recognition. The road to AGI involves integrating capabilities like reasoning, contextual understanding, and general learning (a team a MIT seems have already obtained some results[14]). Technologies such as neural networks, reinforcement learning, and advanced hardware like quantum computing are paving the way toward AGI. ASI, however, requires breakthroughs not just in computational power but also in understanding consciousness, self-improvement and ethical alignment. Current technologies are stepping stones, but reaching ASI would demand entirely new paradigms.

Food for thought

AI, while evolving very quickly, is fundamentally distinct from human intelligence (considering ChatGPT, it doesn't appear so evident), excelling in specific, data-driven tasks but lacking common sense, ethics and emotions. Its progress is based on three pillars: algorithms, large datasets, and computing. However, challenges like the physical limits of transistors, memory bottlenecks and energy inefficiency constrain scalability. Biases in data and algorithms further limit AI's reliability. Future advancements may depend on innovative hardware, such as 3D chips, optical computing, alongside tailored, task-specific models, and certainly on solutions not based on semiconductors but based on or inspired by biology. The Chips JU represents the right initiative to further investigate and develop the next generation of AI technology stacks, and I hope this article will stimulate our community to innovate collaboratively, addressing the challenges that lie ahead in shaping the future of European AI strategic autonomy.

1 https://www.futuretimeline.net/blog/2022/03/20-moores-law-china.htm
2 https://semiengineering.com/is-there-a-limit-to-the-number-of-layers-in-3d-nand/
3 https://www.science.org/doi/10.1126/sciadv.adf1015
4 https://medium.com/riselab/ai-and-memory-wall-2cb4265cb0b8
5 https://www.humanbrainproject.eu/en/follow-hbp/news/2023/09/04/learning-brain-make-ai-more-energy-efficient/
6 https://finalspark.com/neuroplatform/
7 https://www.nature.com/articles/s41467-022-35536-3
8 https://youtu.be/bjTJrgp6rFM
9 https://doi.org/10.3389/frai.2023.1116870
10 https://doi.org/10.3389/fsci.2023.1017235
11 https://doi.org/10.1093/brain/awae150
12 https://www.intel.com/content/www/us/en/research/neuromorphic-computing-loihi-2-technology-brief.html
13 https://research.ibm.com/publications/truenorth-design-and-tool-flow-of-a-65-mw-1-million-neuron-programmable-neurosynaptic-chip
14 https://doi.org/10.48550/arXiv.2411.07279

Research Project Highlight

An Open Source Ecosystem Empowering Digital Transformation

Jerker Delsing

A company's success is closely tied to its ability to continually increase the value of its products. To remain competitive, businesses must not only monitor their value streams — balancing both costs and outputs — but also take prompt, decisive action when needed. In today's fast-paced environment, with rapid advancements in logistics and technology, flexibility is essential. By leveraging an open ecosystem that overcomes protocol and semantic challenges, one can seamlessly embrace digital transformation without costly infrastructure changes, unlocking significant savings and new revenue opportunities. The combined open source technologies refined in the Arrowhead fPVN project track, provide businesses with the necessary capabilities to efficiently optimise and adapt their operations.

Digitisation vs. Digitalisation vs. Digital Transformation

There can be confusion between the meanings of digitisation, digitalisation and digital transformation. However, these three concepts vary in terms of their objectives and outcomes. So let us first just pin down each concept by simply stating their purpose and outcome.

- **Digitisation** involves converting analogue information into a digital format, primarily to record data for use in digital systems.
- **Digitalisation** goes a step further, focusing on how this digitised data can be used to improve processes, often through automation and more efficient workflows.
- **Digital transformation**, however, is about integrating this knowledge across all business functions, enhancing engagement, and creating new value by optimising the entire value chain.

In essence, digital transformation is more than just digitising processes. It's about digitalising operations—using data to optimise everything from the shop floor to executive decisions. This is the core focus of the **Arrowhead fPVN (flexible product value network)** project, funded by the European Union. The project showcases this transformation in various industries through real-world use cases. A significant benefit is that companies don't need to overhaul their existing infrastructure; instead, they integrate information flows, empowering stakeholders to use data effectively across all business areas, leading to enhanced engagement and create new value.

Not just another IoT solution

The project also reviews relevant industry standards, tackling challenges in communication and semantic interoperability. To facilitate this, the project supports the development of an upper ontology and the translation between different information models, leveraging the capabilities of the Arrowhead framework.

This one is more than just another IoT automation solution; it is a comprehensive ecosystem that manages the information flows of all stakeholders while incorporating an upper ontology aligned with ISO 23726, part 3. Rather than being a disruptive technology, the Arrowhead framework is transformative, integrating existing solutions to facilitate information processing across various workflows. In doing so, it drives digital transformation by harnessing information and knowledge to boost engagement and create new value for businesses and society alike. This bold vision invites scrutiny, ensuring its credibility and acceptance.

Let us start by reviewing the IoT element to which we will add the ideas of ontology and semantic models, examining how these concepts contribute to optimising the utilisation of resources in various contexts, including cost insights and environmental impact.

Local cloud

As an IoT automation solution, the Arrowhead framework introduces few novel concepts, apart from the idea of a local cloud. However, its key feature lies in exposing an asset's capabilities as services in a service registry. For instance, a temperature sensor's ability to measure temperature is offered as a 'temperature service', accessible via a specific URL using an internet protocol

The asset does not have to be a physical entity; it can be a database, for example. The database services include creating, retrieving, updating and deleting records. Additionally, an asset could be a PID controller, like a thermostat, which utilizes services from both temperature and radiator assets. The thermostat system, comprising the asset and its software interface, discovers relevant services by communicating with the Orchestrator system, which coordinates with the Service Registrar and Authorization systems. This is very similar to a person using a search engine to find an item to purchase that has been registered.

The idea of a local cloud offers several advantages. Having a limited scope, it is easy to manage and should be able to function without being connected to the internet. It enables to systems to communicate directly with each other keeping latency low through a server-client or publish-subscribe relationship. It also offers security as communication is limited to intra-cloud. Communication with the outside world is done through the Gatekeeper system and workshop operation with the workflow manager enables workshop scheduling to be optimised.

Ontologies …

An ontology for the Arrowhead Framework has been developed to semantically model a local cloud at runtime. This ontology classifies systems, services, assets, and their relationships. When modelling assets, the ontology refers to ISO 23726 and its Industrial Data Ontology (IDO) for semantic alignment. For instance, a temperature sensor may be modelled as an instance of a 1-wire temperature sensor, which is a subclass of a sensor, as defined in the SOSA ontology, aligned with IDO. Similarly, physical plants can be semantically modelled using IDO.

… and semantic models

The use of semantic models as formal AI solutions is not always immediately obvious. These models can be applied when handing over a new plant to a customer, ensuring it meets the specified requirements. During operation, the plant can be monitored, and reasoning can be applied to verify if operations remain safe in the event of component failures. The model has the potential to continuously perform Failure Mode and Effects Analysis (FMEA) during runtime. Currently, these semantic models are ingested into graph databases, creating knowledge graphs that enable querying and tracing, which is crucial for maintaining large-scale industrial plants.

Insights

The Arrowhead framework also offers detailed cost insights for relevant services, such as milling three millimetres from a steel block or maintaining a room temperature of 19°C in winter. It also tracks the environmental impact of these services, including CO_2 emissions. Using the knowledge graph, this data can be leveraged to analyse total costs, value chains, and value streams. In a smart city, for instance, electricity pricing can be used to adjust thermostat settings, helping users save money while reducing strain on infrastructure and the environment. This same methodology can be applied in industrial contexts.

Embracing digital transformation

The Arrowhead Framework also facilitates interactions between stakeholders, ranging from information requests and quotations to payments, in compliance with standards such as the European Standard for Electronic Invoicing (EN 16931). Whatever communication protocol your devices and information systems use, they can communicate seamlessly and understand what they mean. This is made possible by using the open source Arrowhead framework and ISO 23726-Part 3 (Industrial Data Ontology, IDO). Ultimately, then, the message of the Arrowhead framework, and the fPVN project track in particular, is that if your company not only wants to stay competitive but also wants to boost its value streams, the use of combined open source technologies as embodied in the Arrowhead framework will provide the kind of leverage you need. It's the affordable and practicable solution to operational optimisation.

A few key concepts explained

- The ecosystem combines the **Industrial Data Ontology (IDO)** with the Arrowhead framework, working together to provide seamless interoperability and digital transformation capabilities.
- An **ontology** is a structured classification of 'things' and the relationships between them. It defines categories and how these categories connect.
- A **semantic model**, on the other hand, uses ontologies to classify specific instances of these 'things' and their relationships in real-world contexts.
- **Proportional-Integral-Derivative** (PID) control is the most common control algorithm used in industry and has been universally accepted in industrial control. The popularity of PID controllers can be attributed partly to their robust performance in a wide range of operating conditions and partly to their functional simplicity, which allows engineers to operate them in a simple, straightforward manner.
- A **value chain** is a progression of activities that a business or firm performs in order to deliver goods and services of value to an end customer. The concept comes from the field of business management and was first described by Michael Porter in his 1985 best-seller, *Competitive Advantage: Creating and Sustaining Superior Performance.*

Research Project Highlight

OpenContinuum Project

Albert Seubers

For two years, OpenContinuum addressed the coordination and support of research and innovation actions regarding the Cloud-Edge-IoT domain, with a specific thematic focus on the supply side of the computing continuum landscape.

An integrated, open ecosystem was built around open source and open standards, with a community of more than 50 research projects covering the European communities for cloud and cognitive computing, Internet of Things (IoT), meta-operating systems, swarm intelligence, cognitive computing and more.

The core ambition of OpenContinuum was to foster European strategic autonomy and interoperability through this open ecosystem for the computing continuum. The supply side nature of OpenContinuum's agenda was oriented towards the themes and focus of the project activities but was not limited to the scope of the community building. The active landscaping and engagement work of the project brought together cloud and IoT communities to define a common taxonomy and understanding of the computing continuum through a published reference architecture. OpenContinuum took responsibility for contributing to standardisation efforts for the computing continuum, which lead – now that the project has come to end – to continued activities on creating a first European standard derived from funded research projects.

The combined view on the supply and demand side of the landscape was created through close cooperation with UnlockCEI via joint taskforces with a focus on strategic liaisons and market engagement.

The main results of the OpenContinuum project are:

- The creation of a consolidated open-source architecture stack that serves as a foundational element in the European computing continuum to support the strategy for European Digital Autonomy through Open Source and Open Standards and to support research projects in maximising the impact of their exploitation strategies.
- The development of a comprehensive landscape mapping tool that categorises assets from projects into research, open source, and commercial products, enhancing visibility into the European computing ecosystem and allowing stakeholders to identify opportunities for collaboration and innovation. The landscape tool provides graphical representation of these assets, implementing different functionalities identified within the Cloud-Edge-IoT continuum architecture.
- The close interaction with industries and research initiatives – as lead by INSIDE as a partner in the OpenContinuum project – which allowed for interactive discussion with industry representatives on the expected added value created by the research project as part of the OpenContinuum community.

Now that the project has come to an end, management of the community will be continued by NexusForum as a coordination project.

https://eucloudedgeiot.eu/

INSIDE workshops

Building Tomorrow’s Innovation

Join Our Community Workshops and Shape the Future of Technologies

Aurélien Dubois-Pham

In today’s rapidly evolving tech landscape, staying ahead requires a shared vision, collaboration and a strong community. This year, INSIDE is hosting a series of thematic workshops to bring together our community in addressing some of the most critical and exciting challenges in RD&I. Through detailed analysis, collaborative brainstorming and strategic planning, these workshops will aim to enhance project proposals, sharpen our focus and explore the frontiers of emerging technology.

Workshop Series

Budapest, Hungary – June 2024

We kicked off the workshop series at the Budapest University of Technology and Economics (BME) in June 2024. This inaugural event focused on setting the stage, outlining our objectives and exploring our primary focus areas.

Cagliari, Italy – October 2024

Our second workshop took place in Cagliari, Italy, in conjunction with the EDGE AI conference. This follow-up gathering allowed participants to reconnect, evaluate progress and refine ideas, leveraging the presence of the broader EEAI community.

Next steps

Following the two physical events, dedicated working groups will continue to meet through regular online teleconferences, keeping momentum strong and proposals on track. These virtual meetings offer a flexible way for all community members to stay actively involved and contribute in meaningful ways. The working groups will physically meet again at EFECS in Ghent on the 5th and 6th of December.

Why Join Us?

Our mission is to gather a cohesive community around transformative technologies. The workshops will create a platform where experts, innovators and contributors can:

- Envision tomorrow’s innovation projects: imagine the next breakthroughs and help charting a clear path forward.
- Improve project proposals: by working together, we can enhance the quality and impact of each proposal.
- Focus on key technology areas: each workshop will target critical technology domains, allowing us to dig deep, study key areas and analyse their potential.

Workshop Goals

Our workshops aim to:

- Study and analyse key technology areas to delve into the technology areas that are vital to our community’s growth.
- Identify challenges and opportunities, to recognise emerging challenges and leverage them as opportunities for innovation.
- Brainstorm and prepare project proposals, collaborating to draft, critique and refine impactful project proposals.
- Contribute to the ECS-SRIA: the workshops play a part in advancing the European Components and Systems Strategic Research and Innovation Agenda (ECS-SRIA[1]), a cornerstone of Europe’s tech-driven future.

Technology Focus Areas

Our community has identified five pivotal technology areas that are set to shape the discussions and outcomes of each workshop:

- Edge to Cloud Cognitive Continuum
- ECS for Healthcare
- AI-Based Engineering Automation
- ECS for Mobility
- Safety and Security in System of Systems

Get Involved: Shape the Future of Technology

We are an open community, actively seeking new organisations, experts and enthusiasts to join us. If you’re interested in making an impact, helping craft the next wave of project proposals and working within any of the technology areas above, we invite you to get involved.

> Staying ahead requires a shared vision, collaboration and a strong community

Interested? Reach out to us today!

Contact us at the following email and let us know which focus areas resonate with you. Let’s build tomorrow’s innovations, together.

info@inside-association.eu

[1] https://ecssria.eu/

INSIDE Magazine 8

Aurélien Dubois-Pham

Strengthening Europe's Competitiveness

The vision and challenges ahead

Europe is currently united in its pursuit of inclusive and sustainable economic growth, anchored in principles such as sustainable competitiveness, economic security, open strategic autonomy, and fair competition. The European Union envisions a future where businesses thrive, the environment is safeguarded, and opportunities are accessible to all members of society. This dedication is highlighted by an emphasis on productivity, resilience, and innovation, all stemming from the understanding that enhancing Europe's competitive edge is essential to maintaining its status as a significant global player.

To this end, former European Central Bank President Mario Draghi was commissioned to draft a report outlining a strategic path forward for European competitiveness. This ambitious 400-page document provides a comprehensive blueprint, identifying challenges, areas for reform, and policy recommendations. Draghi's vision seeks not only to close the gap with global economic powers but to address Europe's shifting geopolitical context by aligning economic strategy with the broader goals of energy independence, defence integration, and sustainable industrial growth.

Transforming Innovation and Research

At the heart of the blueprint is the need to revamp Europe's innovation ecosystem. To this end, Draghi recommends the creation of a European version of the U.S. Defense Advanced Research Projects Agency (DARPA) to drive breakthrough technologies. Modelled after DARPA, this agency would be more agile, independent, and mission-focused, operating through programme managers with the freedom to channel funds toward high-risk, high-reward innovations. While the European Innovation Council (EIC) was intended to fulfil this role, Draghi argues that it lacks the necessary independence and speed, requiring an overhaul to deliver on disruptive technologies.

This new European ARPA would complement current initiatives by increasing funding, streamlining R&D frameworks, and implementing challenge-driven competitions where innovators compete to develop cutting-edge solutions. By encouraging risk-taking and fostering an environment for radical inventions, Draghi envisions a robust innovation landscape that would retain Europe's top tech firms – many of which are currently migrating to the United States due to better funding and regulatory conditions.

Aligning Decarbonization with Competitiveness

In the wake of the energy crisis, Europe has faced escalating energy costs that jeopardize its industrial competitiveness. While the EU has committed to a carbon-neutral future, Mario Draghi emphasizes the need to balance decarbonization with economic viability.
He proposes a reform of the European electricity market to pass on the benefits of clean energy to consumers and businesses, thus ensuring European industries remain competitive against global rivals.
Moreover, Draghi suggests an industrial policy supporting clean technologies and electric vehicles, crucial for both sustainability and job creation in key sectors like automotive, aerospace, and high-tech manufacturing. By integrating these measures with EU-wide policies, Draghi hopes to foster a self-sustaining clean energy economy, reducing dependence on non-European technology suppliers and enhancing energy security.

Advancing Defence and Economic Security

Given Europe's vulnerabilities amid global tensions, a revitalised and integrated European defence industry is needed. Currently fragmented, Europe's defence sector would benefit from scale and demand aggregation, potentially coordinated through

‘Europe is facing a world undergoing dramatic change. World trade is slowing, geopolitics is fracturing and technological change is accelerating’

(Mario Draghi)

an EU Defence Industry Authority. By centralising procurement and promoting ‘buy European’ incentives, this approach could strengthen the bloc’s autonomy in defence capabilities and reduce dependency on non-EU suppliers.

In addition to this recommendation, Draghi stresses the importance of strategic autonomy in critical supply chains and raw materials, urging a foreign economic policy that fosters resilience against economic coercion by third countries. Greater investment in defence and securing essential resources would enhance Europe’s bargaining power and economic sovereignty.

Financing the Vision

To achieve these ambitious goals, Draghi estimates additional annual investments exceeding €800 billion, approximately 5% of EU GDP. He recommends harnessing private capital through integrated European capital markets, alongside public funds, to finance necessary infrastructure and innovation projects. Alongside this, Mario Draghi advocates for greater EU fiscal capacity, including the possibility of joint European debt, a proposal that has faced resistance, particularly from northern EU countries wary of shared financial obligations.

Other key recommendations include simplified regulations for small and medium enterprises (SMEs) and reforms in competition policy to foster ‘European champions’. Draghi believes that these steps can enhance economic resilience, promote

scaling in essential industries, and position Europe more favourably against global competitors.

Challenges and Opportunities Ahead

While the Draghi report has garnered substantial interest, its success hinges on the navigation of political complexities. Member states remain divided on issues such as joint financing and further integration, with some fearing competition with national initiatives. Funding constraints and budgetary disagreements could also impede the implementation of certain proposals.

However, the urgency of Europe’s economic and geopolitical situation may drive momentum. With Germany facing economic challenges and the EU’s need for a coordinated response to external threats, Draghi’s report could serve as a critical roadmap. His recommendations align well with the strategic priorities of the upcoming European Commission, and his influence may help rally support across European capitals.

Conclusion

Such a comprehensive plan may seem overly ambitious, but these efforts to bridge the gap between ideals and actionable policies offer the EU a pathway to retaining its relevance on the global stage, fostering resilient growth, and creating a sustainable economic model that benefits all Europeans. Whether these proposals will gain the necessary political support remains to be seen, but the Draghi report has, at the very least, set the stage for a decisive moment in Europe’s pursuit of competitiveness and cohesion.

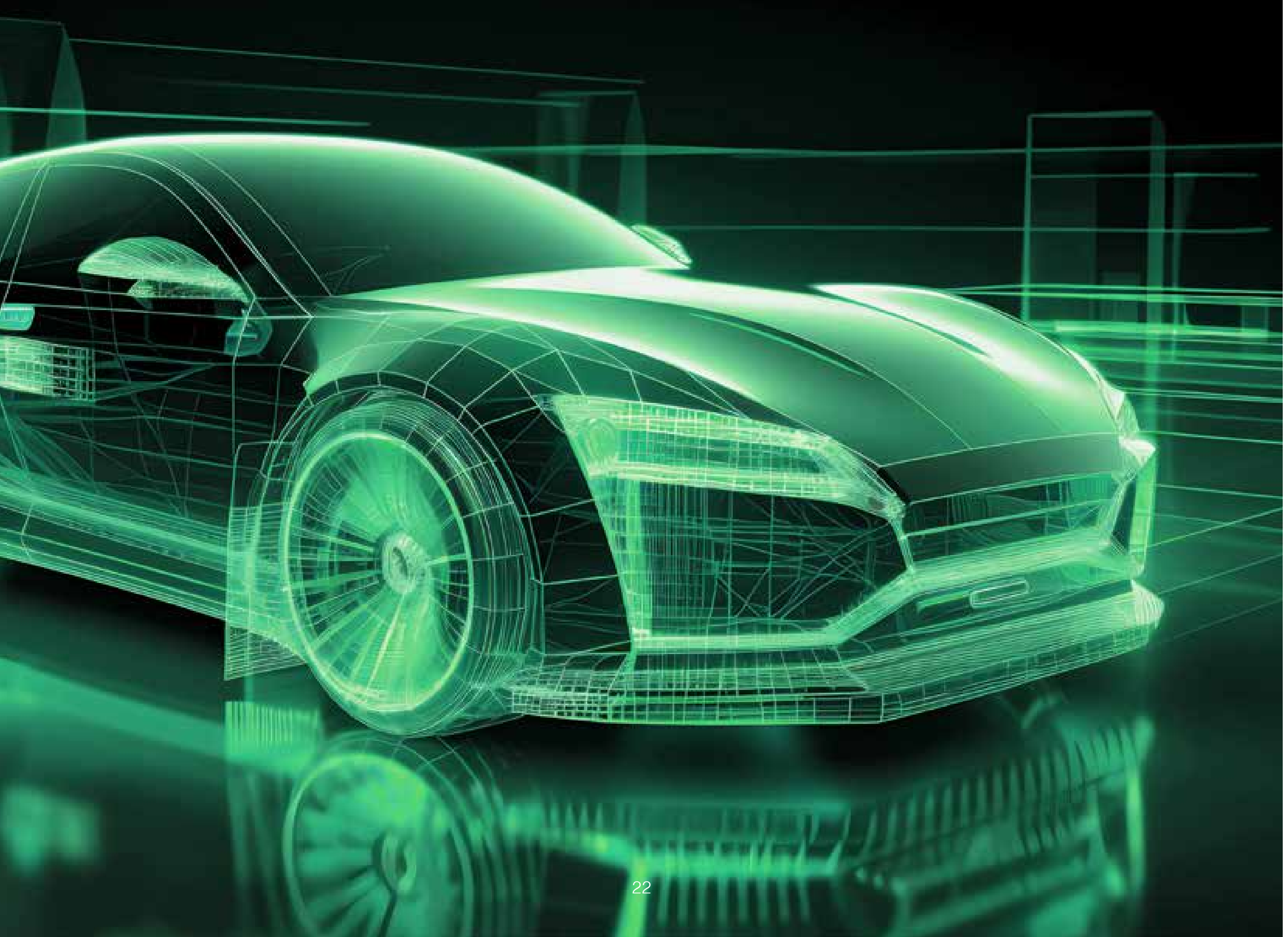
https://commission.europa.eu/topics/strengthening-european-competitiveness/eu-competitiveness-looking-ahead_en

Research Project Highlight

HAL4SDV Project

Andreas Eckel

Advancing Europe's Leadership in Software-Defined Vehicles and Future Mobility



HAL4SDV Systems Safety Security Software

European companies, research and academic organisations join forces in the development of software-defined vehicles in the groundbreaking Chips JU Project, HAL4SDV.

In line with the EU Strategic Research and Innovation priorities on Electronic Components and Systems, key European industrial companies, research organisations and academic institutions from eleven countries started a three-year project to pioneer innovative methods, technologies and processes for series vehicle development beyond 2030.

The HAL4SDV project mission is to advance European solutions in software-defined vehicles (SDV) and next-generation vehicles. It aims to harmonise efforts across Europe, creating a comprehensive SDV ecosystem while leveraging existing national projects and international R&D activities. By focusing on unifying software interfaces and development methodologies, HAL4SDV will enable software configuration that abstracts from vehicle hardware, paving the way for a 'software-defined vehicle' approach for both safety-critical and non-safety-critical applications in future vehicles.

The HAL4SDV consortium, led by TTTech Computertechnik AG including TTTech Auto AG, comprises leading OEMs for shaping the vision and strategic requirements, Tier1 companies keenly interested in exploiting the project's results, integrated design manufacturers driving SDV integration in computing platforms, software and technology providers offering critical expertise, SMEs contributing specialised knowledge, and academic partners and research institutes bridging fundamental and applied research.

With the joint efforts of fifty partners, three affiliates' and ten associates, the HAL4SDV project is ready to shape the future of mobility, secure Europe's leadership in the automotive sector, and drive progress toward a more connected, efficient and environmentally conscious future in the automotive sector. Moreover, it responds to the pressing need for Europe to invest massively in technological leadership in the automotive domain, ensuring the region's future growth and prosperity.

The main HAL4SDV objectives include:

- SDV platform Service oriented Architecture (SoA), serving non-safety and safety-related applications
- HAL architecture definition in the context of a comprehensive 'System + Software' approach
- Hardware Abstraction Layer (HAL) developments – standardized interfaces to sensors, actors, compute resources and persistent storage, abstraction using hypervisors, HAL SW updates
- Hardware abstraction layer of key software element updates
- HAL for secure enclaves to develop Zero Trust concepts
- Cloud-based rapid prototyping for software-defined vehicles
- Security support for automotive safety-relevant applications, etc.

The project's objectives are both comprehensive and far-reaching, spanning the unification of software interfaces and the creation of a robust hardware abstraction framework, facilitating Over-The-Air (OTA) updates, designing advanced platform architectures, and the provision of essential development tools. These objectives are pivotal in ensuring the agility and adaptability of the European automotive industry to meet the demands of the future.

Beyond technological innovation, HAL4SDV underpins Europe's automotive industry, sustains its competitive edge, and accelerates green and digital transitions, both fostering collaboration and promoting sustainability across the automotive ecosystem.

HAL4SDV website: www.hal4sdv.eu.

ACKNOWLEDGMENT: HAL4SDV is supported by the Chips Joint Undertaking and National Authorities under grant agreement n° 101139789.

Co-funded by the European Union

Chips JU

Research Project Highlight

CEI-Sphere

Supporting Europe's Cloud-Edge-IoT Ecosystem Through Large-Scale Pilots

Tanya Suarez

In alignment with Europe's strategic objectives for digital transformation and technological sovereignty, the CEI-Sphere project, funded by the Horizon Europe programme, was recently launched on 1st October 2024.

As a Coordination and Support Action (CSA), CEI-Sphere seeks to advance the integration and interoperability of Cloud-Edge-IoT (CEI) ecosystems across Europe. This project supports the goals of several key European initiatives, including the European Data Strategy, the Next Generation Internet (NGI) initiative, the Next Generation Cloud Infrastructure and Services (IPCEI-CIS) and the Chips Act, which together aim to secure Europe's leadership in emerging technologies and ensure its competitiveness through secure, sovereign, and resilient digital infrastructures.

Moreover, CEI-Sphere operates under the umbrella of the EUCloudEdgeIoT initiative, which is fostering collaboration across sectors to build a unified, scalable, and interoperable CEI computing continuum. Through the support for two large-scale pilots (LSPs) starting in January 2025, CEI-Sphere will help to demonstrate the practical benefits of an integrated CEI infrastructure, particularly in the energy sector. These pilots will address sector-specific challenges while contributing to the broader European effort to promote sustainability, innovation, and technological autonomy.

The supported pilots

CEI-Sphere will play a pivotal role in orchestrating these pilots, promoting their open calls and bringing together key stakeholders, technology providers, and policymakers to ensure the scalability, interoperability, and sustainability of the CEI infrastructure. More precisely, as part of this mission, the project will focus on two key LSPs: **O-CEI** and **COP-PILOT**:

- **O-CEI** will focus on enhancing edge computing in large-scale energy pilots as the backbone of several other industrial applications, promoting energy efficiency, flexibility, and data sovereignty. This pilot aims to foster a federated marketplace for innovative cloud-edge technologies.
- **COP-PILOT** will develop an open multi-layer orchestration platform to support large-scale pilots across IoT-to-edge-to-core systems. This platform will prioritise interoperability, sustainability, and business model innovation across industries, providing a template for scalable cloud-edge solutions.

CEI-Sphere goals

The project focuses on gaining a detailed understanding of use cases, value chains, and markets, promoting interoperability and ensuring the following goals:

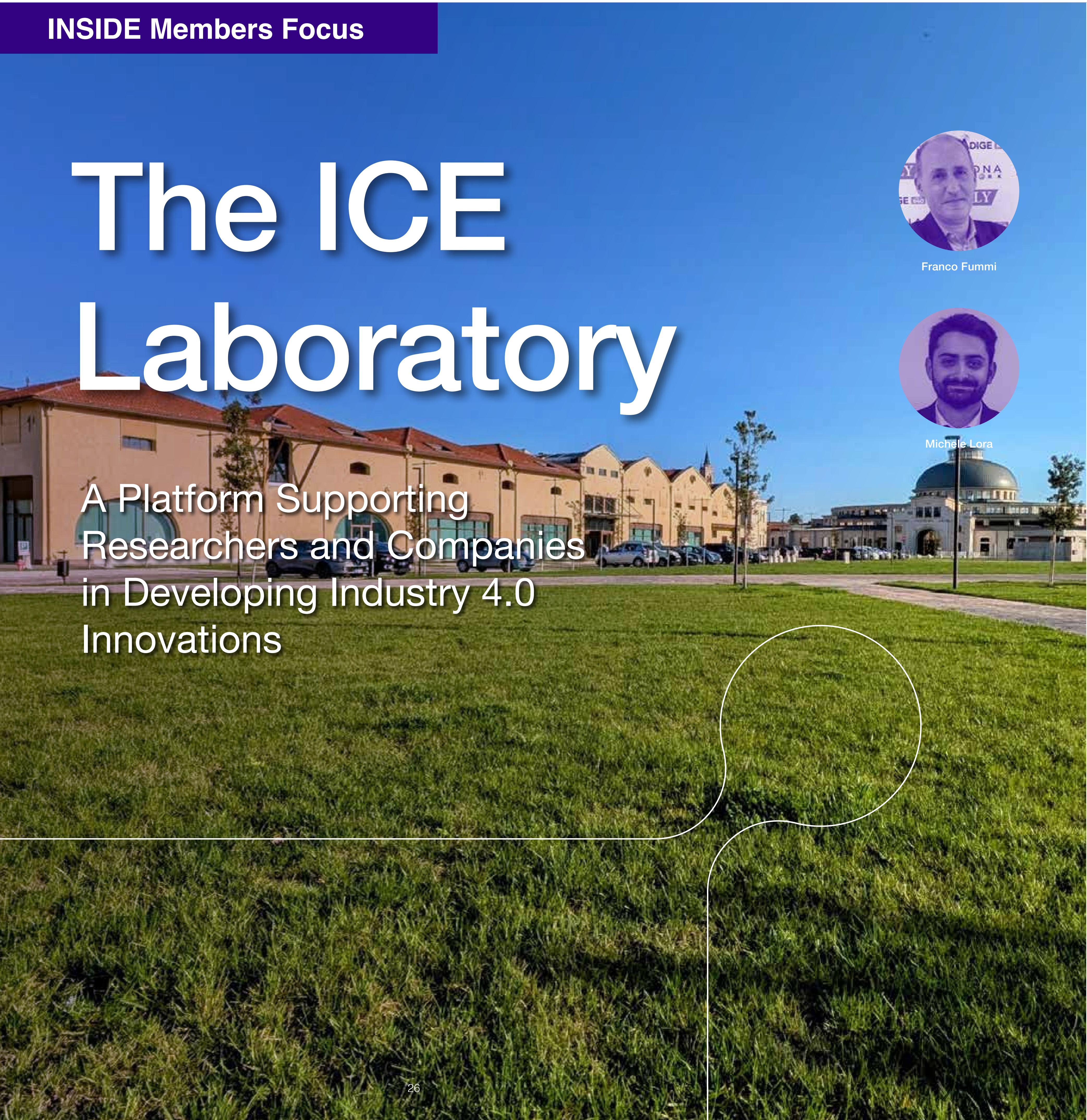
- **Market analysis and pilot preparation:** In the initial phases, CEI-Sphere will conduct in-depth market research to better understand the opportunities and challenges faced by LSPs. This analysis will later feed into the creation of tailored go-to-market (GTM) strategies, helping to ensure that the pilots are aligned with industry needs.
- **Stakeholder engagement:** CEI-Sphere will foster collaboration through workshops, hackathons, and strategic events, bringing together stakeholders from various sectors to co-create solutions and address common challenges.
- **CEI reference architecture:** CEI-Sphere will develop a reference architecture, building on the work previously carried out by the EUCloudEdgeIoT Task Force 3 that aligns with European standards and supports long-term infrastructure development.
- **Use case catalogue:** CEI-Sphere will produce a catalogue featuring 50+ use cases, highlighting diverse applications of cloud-edge solutions and supporting market analysis.
- **Standardisation and certification:** A key element of the action plan involves establishing a certification framework to ensure the quality, security, and interoperability of cloud-edge infrastructure across Europe and working closely with standards development organisations (SDOs) to ensure the scalability of CEI solutions across Europe and the international competitiveness of European CEI solutions.

Action plan and initial milestones

CEI-Sphere will focus on the following key milestones during its first year, ensuring a solid foundation for the launch of the pilots and the establishment of a broader engagement framework:

1. **October 2024 – Project Kick-off Meeting**
   The project was officially launched with all consortium partners during an online meeting held on 10th October. The meeting provided strategic priorities for the project, ensuring alignment with EU policy objectives.
2. **November 2024 – Joint Workshop with INSTAR**
   CEI-Sphere will hold its first in-person event in Brussels: a cross-domain standardisation workshop on edge computing, co-organised with the INSTAR project and the European Commission – DG Connect. This will be a key event for stakeholders from multiple sectors to align on standards and architectures.
3. **January 2025 – Launch of the LSPs**
   A dedicated landing page, launched at the beginning of the project, will further echo all of the necessary updates related to the LSPs that will be launched in January 2025, providing access to project resources and support tools in sync with existing EUCloudEdgeIoT materials. This will enhance visibility and outreach to a wider community of stakeholders to properly set the scene for the kick-off of the two pilots.
4. **May 2025 – Clustering and Engagement Framework**
   A framework for clustering and engaging key stakeholders of the LSPs will be presented at a workshop, aiming to secure agreements and facilitate smooth pilot launches. This framework will include rules of engagement for continued collaboration.
5. **September 2025 – CEI-Sphere Innovation Ecosystem Strategy**
   The CEI-Sphere Innovation Ecosystem Strategy will be launched, providing a toolkit and an ecosystem visualisation tool to support open calls across the LSPs.

INSIDE Members Focus
INSIDE Magazine 8



INSIDE Members Focus

The ICE Laboratory

A Platform Supporting Researchers and Companies in Developing Industry 4.0 Innovations

Franco Fummi

Michele Lora

In today's manufacturing landscape, digital devices are transforming factory operations at an unprecedented pace. From smart sensors to AI-powered machinery, technology is increasingly integrated into production processes, marking the beginning of a new industrial era. Known as 'Industry 4.0', this revolution is defined by the convergence of automation, data exchange, and advanced digital tools, fundamentally reshaping production lines and workflows. Central to this transformation is the pervasive need for semiconductor chips, which power everything from robotics to IoT devices. As industries rely more heavily on these technologies, the demand for chips continues to surge, underscoring their critical role in driving efficiency and innovation across sectors.

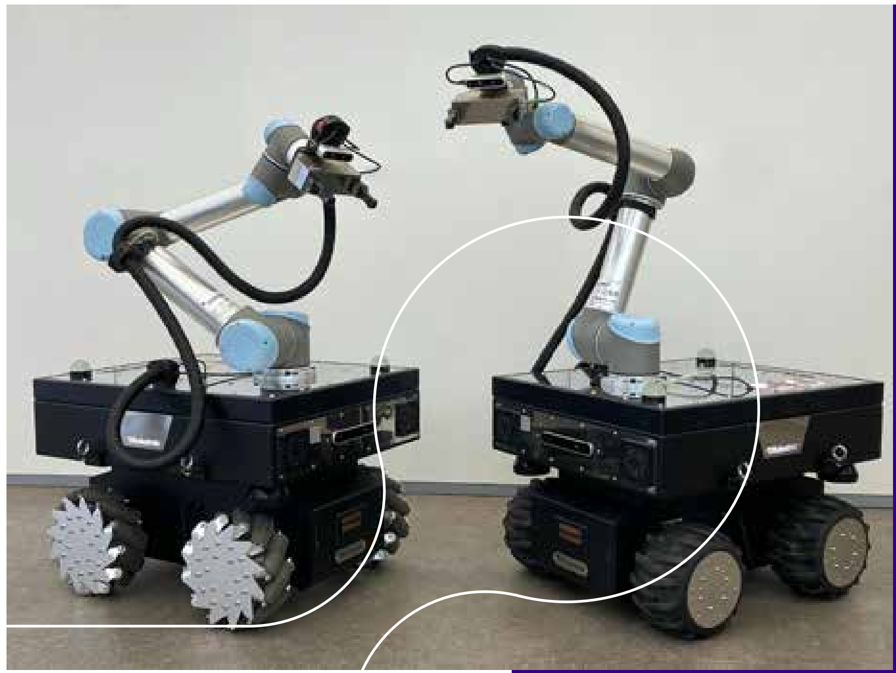
Established in 2018, the Industrial Computer Engineering (ICE) Laboratory aims to foster synergy between technological innovations in smart manufacturing and educational and research initiatives by providing a development and experimentation platform for creating computer engineering solutions for advanced manufacturing. This facility is part of the IT Excellence Project, which received €8 million in funding from the Italian Ministry of Education, Universities, and Research. The laboratory is managed by the Engineering and Physics section of the Department of Engineering for Innovative Medicine at the University of Verona—a department specifically created to explore the application of digital technologies and advanced manufacturing in advancing innovation in medicine.

The ICE Laboratory, situated in the newly redeveloped industrial architecture area, overlooks the park and stands near Verona's historic icehouse. Just as the icehouse once played a central role in the city's economic life, the ICE Laboratory now stands at the heart of Verona's future technological development, driving innovation and fostering growth in the local economy. The lab serves as a vital hub for collaboration between companies and research institutions, offering state-of-the-art facilities for testing and prototyping new technologies in a controlled and secure environment. Companies may deploy their technology in the ICE Laboratory, while researchers can guide them toward innovative solutions. By functioning as a technology demonstrator, the ICE Laboratory enables organisations to showcase their innovations through live demonstration sessions, providing an invaluable platform for engaging with stakeholders and the public.

The Laboratory structure and philosophy

The ICE Laboratory features a diverse array of technologies, with a focus on a reconfigurable production line made up of various work cells. Central to this setup is a robotic assembly cell, which employs two robots from different manufacturers that work collaboratively to assemble products. Additionally, a subtractive manufacturing cell houses a multi-tool milling machine, supported by a robotic arm that autonomously loads and unloads components for drilling, milling, or cutting. Product quality is ensured by the quality control cell, equipped with multiple cameras and laser scanners. Furthermore, the electronic testing cell is designed for testing electronic boards and chips, utilising a flying probe testing machine that connects to the logistics system through an automated loading bay.

Raw materials, partially assembled components, and finished products are stored in a fully automated vertical warehouse. The logistics of the production line are managed by a reconfigurable conveyor belt system and autonomous ground vehicles that transport materials and artifacts between the various cells and the vertical warehouse.



The ICE Laboratory bridges cutting-edge research and industrial application, driving Industry 4.0 innovations by fostering collaboration, advancing smart manufacturing, and preparing for a sustainable and human-centric Industry 5.0 future.

The entire laboratory is outfitted with a wide range of sensors, from temperature and humidity sensors to high-end tracking cameras that monitor the movements of personnel within the system. The software architecture governing the ICE Laboratory is built on service-oriented manufacturing paradigms, where each piece of equipment exposes its functionalities—such as manufacturing actions performed by machines or data provided by sensors—as services that can be requested by the controlling software. This interconnected infrastructure relies on a data integration hub utilising various state-of-the-art communication protocols, including OPC UA and communication brokers, to facilitate seamless interaction across the system.

The diverse set of technologies, protocols, and technology providers sets the ICE Laboratory apart from other research facilities with similar objectives. Many research laboratories typically rely on a single technology provider to create an ad-hoc, research-oriented mock-up factory or they avoid integrating their equipment into a cohesive system altogether. In contrast, real manufacturing systems are often a collection of various machines from different manufacturers, communicating through distinct protocols and exchanging diverse data models. When designing the production line at the ICE Laboratory, we aimed to replicate the environment found in most local factories as closely as possible. This led us to embrace the challenge of heterogeneity. By doing so, research groups in the ICE Laboratory can address a wide range of issues that are often overlooked by other institutions, thus developing a unique skill set that proves invaluable when collaborating with local companies transitioning to Industry 4.0.

The expertise of the ICE Laboratory is further enhanced by the active involvement of multiple research groups from the Department of Engineering for Innovation Medicine at the University of Verona. Notably, the Electronic System Design group, led by Prof. Franco Fummi, contributes its knowledge in model-based design, simulation, testing, and validation to initiatives related to automatic software generation, the development of digital twins, automatic code generation, and the verification of production systems. The Parallel Computing (PARCO) Laboratory, under the direction of Prof. Nicola Bombieri, specialises in programming for advanced computer architectures, focusing on the development of the artificial intelligence software used within the ICE Laboratory. The Altair laboratory, led by Prof. Riccardo Muradore, shares its expertise in robotics with the ICE Laboratory. Additionally, the INTELLIGO Labs, led by Profs. Marco Cristani and Andrea Giachetti, provide expertise in artificial intelligence and advanced human-machine interaction as applied to industrial contexts.

Together, these research groups form a robust interdisciplinary collaboration that not only strengthens the ICE Laboratory's capabilities but also fosters innovative solutions that bridge the gap between technology and practical application in the evolving landscape of Industry 4.0.

Success stories and ongoing projects

The need to tame the heterogeneity in technologies and technology providers that characterise the ICE laboratory compelled the teams responsible for maintaining and developing it to create a substantial number of software solutions. This extensive effort has resulted not only in scientific publications but also in practical applications currently deployed in real production facilities, along with the establishment of multiple spin-off companies that translate research outcomes into commercial products. Notably, FACTORYAL develops service-oriented manufacturing software solutions designed to enable smart manufacturing within legacy production systems, while QUALYCO offers software solutions focused on autonomous quality control and anomaly detection in manufactured products.

Since its inception in 2018, the ICE Laboratory has engaged over 100 companies in more than 40 research projects. Among these are the 'Design automation for smart Factories' (DeFacto) project, funded by the European Commission, which utilised techniques from the electronic design automation (EDA) field to design cyber-physical production systems. The ongoing 'STRATEgic GUide to Smart Manufacturing' (STRATEGUS) project, also funded by the European Commission, aims to develop techniques and software architectures for integrating new technologies within production systems. The OPERA 4.0 project addresses workplace safety from various angles, leveraging data collected from the field and cameras installed in the laboratory. Meanwhile, 'Virtualisation and Remote operations for Resilient and Efficient Manufacturing, Virtualisation and Remote operations for Efficient and Resilient Manufacturing' (VIR2EM) focuses on the virtualisation of industrial processes to enable remote operations, enhancing process resilience. Lastly, the SMART-IC project employs various artificial intelligence techniques to facilitate dynamic reconfiguration in semiconductor production lines, aiming to utilise data gathered during the functional testing phases of chip production to make integrated circuit manufacturing more efficient and reduce waste and inefficiencies.

Future vision and plans

As we transition from Industry 4.0 to Industry 5.0, the emphasis shifts from solely optimising efficiency and automation to cultivating a more sustainable and human-centric approach to manufacturing. The ICE Laboratory is embracing this transformation by implementing collaborative robotics, exploring strategies to reduce production waste, and enhancing the focus on data that evaluates the environmental footprint of production systems. As the laboratory aims to be a platform for developing new technologies and techniques, we are currently undergoing an extension of its capabilities in allowing researchers and companies to study and experiment with Industry 5.0 aspects.

Next Generation EU funding is being utilised to enhance the production line by introducing a collaborative robotic cell. This new cell will be equipped with multiple sensing devices and cameras to gather data on human-robot interactions. The insights derived from this data will enable researchers to assess the social and environmental impacts of implementing such technologies. Additionally, the software architecture of the ICE Laboratory will provide companies and researchers with the opportunity to test their software within the framework of human-robot collaboration.

Within the scope of various projects, particularly the SMART-IC project, we aim to develop data-driven methodologies that enhance yield and minimise waste in critical production processes. Specifically, we are focused on optimising the production and testing of semiconductors—a key area that, in alignment with the European Chips Act, will significantly shape the future economic landscape of the European Union.

To overcome the geographic barriers that limit access for potential users of the development platform offered by the ICE Laboratory, we are creating an advanced digital twin and development platform. This initiative aims to provide researchers with a unified framework for developing, testing, and validating new software concepts within the context of advanced manufacturing. By bringing our real-world research platform into the virtual realm, we will enable a broader audience to leverage its functionalities, fostering collaboration and innovation across diverse locations.

INSIDE Members Focus

Seven reasons why Gran Canaria is perfect to develop microelectronics projects

Juan Ramon Rodriguez

The beautiful island of Gran Canaria has many nicknames, one of which is the Island of Eternal Spring due to its average temperature of 22ºC that offers a climate where overly hot summers and harsh winters are notably absent. Additionally, it's known as the 'Miniature Continent' because of its diverse terrains, ranging from the Sahara-like Maspalomas Dunes to the Arizona-esque Roque Nublo. In this article, we'll explore why Gran Canaria is an exceptional location for developing semiconductor, microchip and digital technology.

1.
Join a flourishing r&d ecosystem
Gran Canaria is home to a vibrant R&D ecosystem, with the University of Las Palmas de Gran Canaria's Science and Technology Park (PCT) serving as an ideal base for technology transfer and business spin-offs.

Over the course of more than a quarter of a century, the Institute for Applied Microelectronics (IUMA) has accelerated progress in the industry, helping to draw up the inaugural Spanish Microelectronics Plan in 1985. With 70 researchers spread across labs designing, characterising, verifying, packaging, bonding, inspecting, assembling and testing semiconductor wafers, integrated circuits, printed boards and electronic equipment, IUMA is an invaluable potential partner.

The newer Institute for Technological Development and Innovation in Communications (IDeTIC) dates back to 2010. Here, 65 researchers specialise in signal processing, communication systems and the Internet of Things. IDeTIC pioneers the use of optical and radio-frequency technologies.

Elsewhere, the Institute for Smart Systems and Numerical Applications in Engineering (SIANI) employs 45 researchers. They're committed to cutting-edge theory and practice in numerical techniques and the technology of smart systems, focusing on applying them to engineering. SIANI's research field is Computational Engineering, designing, developing and applying computational systems to provide Physics, Mechanics, Engineering and general Science solutions.

Other research groups and institutes are related to the synthesis of CVD thin-film

semiconductors, photo-catalysts, graphene, sensors and thermoelectric semiconductors and cells.

2.
Access state subsidies and financial support
As well as being able to claim subsidies (regional incentives) from the Spanish Government, there's a new Chip Financing Mechanism (PERTE Chip) you can benefit from if you satisfy any of the following conditions:

- Develop R&D&I on cutting-edge microprocessors and alternative architectures
- Develop R&D&I on photonics or integrated photonics
- Fund Important Projects for Europe in Microelectronics and Communication Technologies (IPCEI ME-TC)
- Create fabless companies for the design of cutting-edge microprocessors, microcontrollers or alternative open hardware architectures.
- Create pilot lines for the manufacturing, characterisation and testing of semiconductors with new substrates, materials or processes, or for advanced packaging, or for semiconductor sensors
- Create education and training facilities and programmes regarding semiconductors and microelectronics
- Have a planned investment of a manufacturing capacity below 5 nm
- Have a planned investment of a manufacturing capacity above 5 nm
- Use an established ICT-equipment manufacturing incentive scheme

3.
Take advantage of tax breaks
In 2023, the average corporate tax rate in Europe was 21.3%. However, if you base your business in Gran Canaria, you can reduce that to as low as 4.0%. How?

This is thanks to the existence of the Canary Islands Special Zone (ZEC), a subsidised tax zone within the Canary Islands Economic and Tax Regime (REF) established by Spain and approved by the European Union to diversify the economy of a region that traditionally has relied heavily on tourism.

If you come from a non-EU country, this is particularly appealing. There's no withholding tax on repatriated dividends. Other combinable incentives are available.

Tax breaks include a 50% deduction on the Corporate Income Tax rate for all goods produced in the Canary Islands. You'll also qualify for a 25% deduction on the Corporate Income Tax rate for investments in fixed assets (excluding land).

The Canary Islands offer the biggest deductions for R&D and TI investments in Spain. Rates start at 45% for Technological Innovation and increase to up to 75.6% for Research and Development activities. Another option is the Canary Islands Investment Reserve (RIC), which eases the tax burden (with up to 90% of undistributed corporate profits in the Canary Islands), but in this option you'll need to reinvest the amount in growth plans for local businesses (especially new fixed assets, new jobs, or R&D).

On this miniature continent, there's the Gran Canaria Free Trade Zone. This supplies customs advantages for the distribution, transformation and storage of goods in the two free economic zones on the island. These are in the ports of the capital Las Palmas de Gran Canaria and Arinaga in the south-east of the island.

4.
Gran Canaria's got talent

You will be able to draw on a rich pool of young and highly qualified talent in Gran Canaria. There's an interesting mix of a university-educated, technically-developed and professionally-trained workforce.

In 2023, nearly 3,000 students were enrolled in STEM-related undergraduate, master and doctorate programmes, with subjects studied ranging from Mathematics, Physics, Mechanics, Chemistry and Materials Science to Computer and IT Engineering, Industrial Organisation, Industrial Automation, Telecommunications Engineering, and Electrical and Electronics Engineering.

Around the same number of students were enrolled in postsecondary professional/ vocational regular courses on Electricity and Electronics, and IT and Communications. Over 500 university students graduate from these STEM subjects every year. And again, more than 500 students graduate from vocational studies every year in this area.

Gran Canaria is a digital nomad hotspot, attracting expats and remote workers from mainland Spain and beyond. The chance to work in sunnier climes is magnetic. This is another way to find top talent on the island.

5.
Choose from a selection of potential sites

The Gran Canaria Science and Technology Park is home to 14,000 m^2 of floor space occupied by tech companies (Polivalent buildings I, II, III, and IV). There's a new multi-purpose building (V) offering 6,000 m^2 of floor space equipped with services, offices and spaces for labs and testing solutions in the fields of electronics, space, information and communication technologies. On campus, there's an extra 30,000 m^2 of land that can be used to build new facilities and labs.

Off campus, there is over 200,000 m^2 of industrial land spread across the island. So, you can opt for a university base in the capital of Las Palmas de Gran Canaria or choose somewhere else on the miniature continent.

6.
Enjoy a great connection

Around 4.4 million visitors travel to Gran Canaria every year, with 54 airlines bringing them to and from our shores. Scheduled direct flights from the United States are on the horizon.

The appropriately-named Puerto de la Luz (Port of Light) of Las Palmas de Gran Canaria is one of the key ports in the Mid-Atlantic and manages part of the traffic at the junction between Europe, Africa and America. It is one of Spain's three main ports and the first in the geographical area of West Africa.

7 .
Embrace a new environment and enjoy a higher quality of life

For centuries, affluent Europeans have been drawn to the Canary Islands, appreciating the health benefits of abundant sunshine and the therapeutic waters of the Atlantic. As a long-term resident, you'll also benefit from access to 15 hospitals and 89 health centers, ensuring comprehensive healthcare services.

If you're relocating with your family, Gran Canaria offers 15 international schools, including American, British, and German institutions. For those opting for state education, the island boasts 245 primary schools and 119 secondary schools, providing quality educational opportunities for all ages.

Gran Canaria is also a haven for food enthusiasts, with Michelin-starred restaurants showcasing culinary excellence. Its capital, Las Palmas de Gran Canaria, is a vibrant city that features Las Canteras, one of the world's finest urban beaches. Coupled with a lower cost of living, the island offers an exceptional quality of life.

Online version is available at Inside-association.eu

Publisher
INSIDE Industry Association
High Tech Campus 69-3
5656 AG Eindhoven, The Netherlands

Design and Creative lay-out
Studio Kraft – Veldhoven, the Netherlands

Acknowledgements
With thanks to the interviewees, project participants, INSIDE Industry Association office, the INSIDE Industry Association Presidium and other INSIDE Industry Association-involved persons for any assistance and material provided in the production of this issue of the INSIDE Magazine.

Contributions
The INSIDE Industry Association office is interested in receiving news or events in the field of Intelligent Digital Systems. Please submit your information to info@Inside-association.eu

INSIDE
Industry Association

INSIDE
Industry Association

INSIDE-association.eu