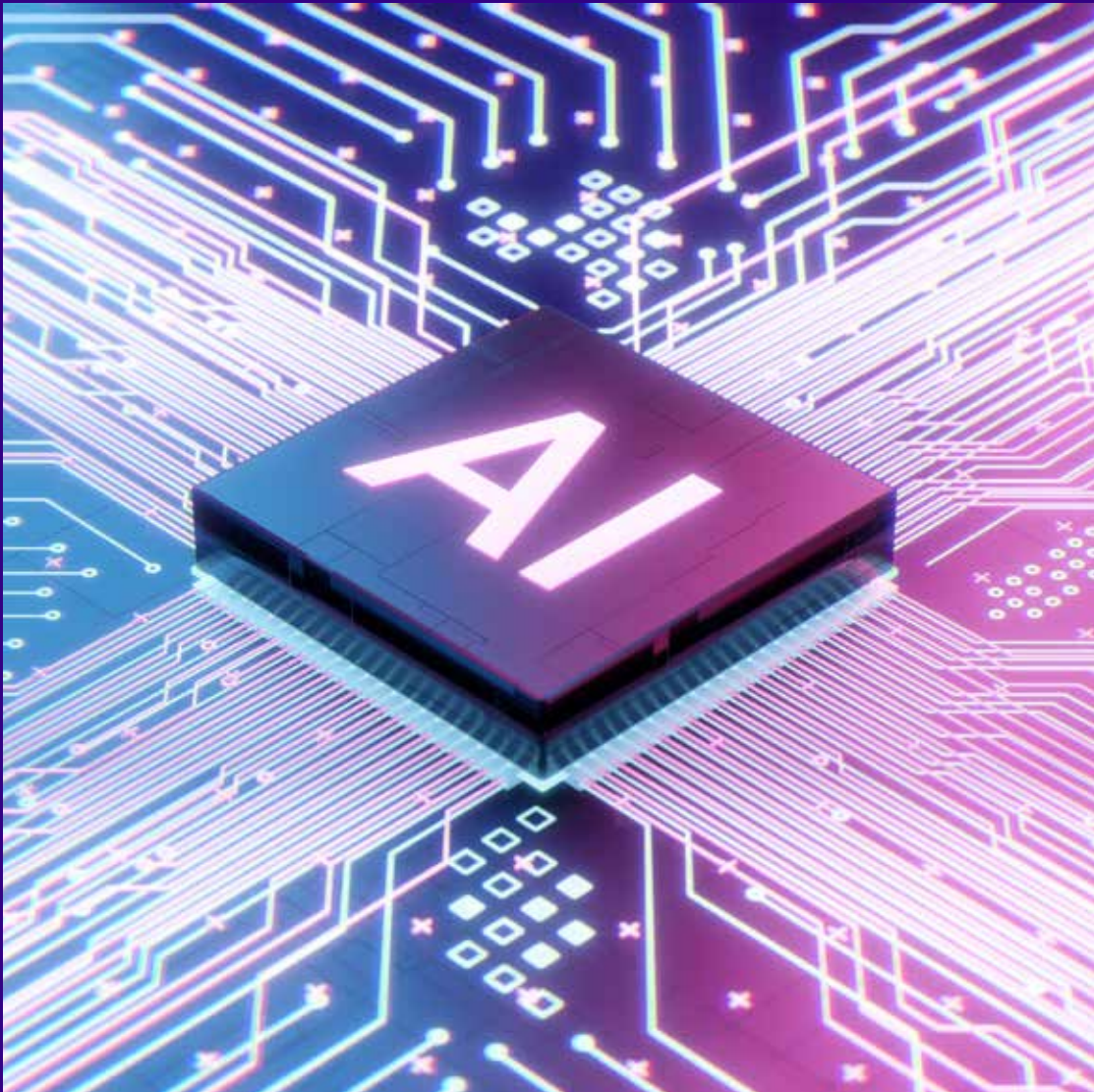


# Inside

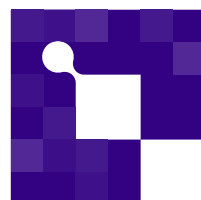
magazine



June 2023 — Issue 04

In this issue:

- **Common sense: the Achilles' heel of AI?**
- **The ECS-SRIA goes online**
- **Managing complexity in cyber-physical systems**



**Inside**  
Industry Association

# In this issue

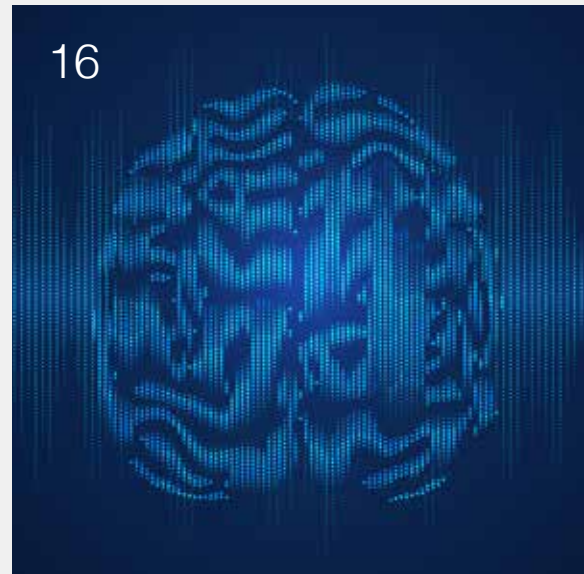
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Dear reader,

Against a backdrop of ever-growing geopolitical tensions, the advent of the Chips Act and the role of AI coming under intense scrutiny, this year is highlighted by a number of significant moments and events for the ECS community, and particularly in the world of Embedded Intelligence, the arena that both influences and is influenced by Inside Industry Association.

This edition of the magazine contains a diverse set of articles in which trends, opinions and commentaries bring insight to these important issues and topics. Such as the place of the very human characteristic of 'common sense' in the makeup of Artificial Intelligence. In this viewpoint the role of ECS in building smaller AI systems that are sustainable and trained on human norms, ethics and values come under investigation. Furthermore, there is a story about a group of friends from the magnificent Sardinia, who used to hang out in a bar and chit-chat about their days, their unenjoyable work, their futures and their desire to live on their island. Using their years of engineering experience in ICT, they changed that chit-chat into ideas and plans to create a new company with a flexible organisational structure that would allow all of them to bring in their competencies and pursue their personal ambitions. That company, Abinsula, has become a very innovative and competitive Italian SME, allowing them to enjoy working on what they like from the place they love.

In a viewpoint article on SMEs, Bert de Jonge, the CEO of Verum, explains how his company deals with the topic of managing complexity which characterises modern embedded software, with a focus on increasing efficiency, reducing errors, improving quality and also rejuvenating software. The objective is to automate the software engineering process, supporting the development, verification, and control of embedded and of cyber-physical systems, where control of devices is critical.

Other highlights in this magazine include the edition 2023 of the ECS-SRIA which we transformed in an online website, significantly increasing the visibility at global level, attracting new experts and talents and improving the reading experience. As every year, the ECS-SRIA isolates the major challenges and priorities for ECS and ECS-based applications, and identifies the required research, design and innovation efforts to address these challenges, defining a potential path to European strategic autonomy, while remaining a live, open and funding programme-agnostic document. The ECS-SRIA reports the industry objectives, the societal benefits and the strategic advantages over Europe for the next 10-15 years.

Ahead of the shift from KDT JU to Chips JU, we report how European strategic autonomy in key domains such as automotive can be achieved by collaboration, resource pooling and more coordination and standardisation across players, in the context of resource scarcity (brains, investments, solutions and materials). The mobility sector will be one of the biggest and fastest growing application sectors requiring electronics and the creation of a roadmap and a focus area for the vehicle of the future represents a strategic asset. The focus area on the Software Defined Vehicle, covering the entire hardware and software technology stack, has been supported by the European Commission and by a significant and sufficient number of public and private stakeholders, demonstrating a concrete way to cover a larger scope of the research value chain, guaranteeing European impact with our social, digital and environmental standards.

From this magazine issue we are also introducing sections, which define key thematic areas for which a special attention will be reserved in every magazine issue. For example, the "Technology Frontiers" section will investigate frontier technologies that could inspire future R&D&I projects in our community. In this magazine issue this section explores the rapid evolution of technologies for monitoring and tracking our physiological and cognitive parameters from a distance, opening unprecedented opportunities in our daily life and in the treatment of neurological disease and suffering, but also introducing new privacy, security and ethical issues, which could undermine human cognitive freedom and protection. The number of companies heavily investing to get access to the brain and quantify what's inside is consistently growing.

Another example is the "Ad Maiora" section, where we introduce leading researchers and innovators: in this issue we present our first female voice of "Technology for Europe", a special figure who has shown herself to be making a difference in the field of nuclear technology and ECS. A talk with Andrea Bachrata Kubic, head of a research laboratory at CEA (Commissariat à l'énergie atomique et aux énergies alternatives), France.

And more sections will be introduced on artificial intelligence, market studies, open-source, etc.

I wish you a good read and encourage you to engage with the topics that are at the core of our community. Let's keep Inside a dynamic setting, where sharing knowledge and exchanging ideas and opinions is an ongoing process, whether through project participation or the more informal channels.

Paolo Azzoni  
Secretary General





# Common sense: the Achilles' heel of AI?





Paolo Azzoni

**Artificial intelligence has reached another hype, with potentially an unprecedented impact on every aspect of our life, causing many to think of AI as a new intellectual species. The new hype is mainly driven by massive artificial intelligence systems, like ChatGPT, which are far from being perfect but represent undeniably powerful tools, capable of playing games and winning, creating new contents (images, audio and videos), generating source code, accelerating the discovery of new drugs, predicting weather and stock market trends, personalising marketing, supporting education, acing college admission tests and even passing the bar exam – the list goes on. ChatGPT has become the fastest-growing app in history, with more than 100 million users in two months and 1.8 billion visitors in three months (02-04/2023). These very large systems, which are estimated to be trained on tens of thousands of GPUs and trillions of words, are based on extreme-scale AI models, called Large Language Models (LLM), consisting of a specific kind of artificial neural network that is trained on enormous quantities of written text (e.g., web pages) to predict the next words that should follow in a given sentence.**

When trained with the right amount of data, complemented with human feedback about good and bad answers, these AI systems appear to show some sparks of Artificial General Intelligence (AGI), being able to generate text and answer questions with remarkable eloquence and apparent knowledge. ChatGPT and other similar chatbots, for example, can hold coherent and impressively fluent conversations, and are capable of answering very general questions on almost every topic, with the appearance of real knowledge and understanding. But they also exhibit biases, fabricate incorrect information, can replicate toxic language from the billions of words used to train them, and can behave in strange and unpleasant ways, frequently failing simple tests in a very puerile way.

Opinion is widespread that “it is just a matter of time” to solve these issues with brute force, more hardware and software resources, and larger datasets. But is this sustainable? Do these issues hide deeper key problems of these cutting-edge large language models? What is the role of ECS in building smaller AI systems that are sustainable and trained on

human norms, ethics and values?  
Let's dig into it...

### **AI challenges**

The first challenge we need to face with AI is the extreme scale of the adopted models, which are excessively resource-demanding and expensive to train, allowing only a few tech companies to afford these systems, with the clear risk of market monopolisation and a complete lack of control on the technology and on its safety. Typically, university and non-profit research organisations can rarely afford a massive GPU-based data centre to create, train and test massive language models. The impossibility for the right representative of the scientific community to thoroughly inspect and dissect the adopted models and check the training methods potentially leads tech companies to misuse AI, spread misinformation, malicious, biased or sensitive contents, with the risk of harming people, the entire society, businesses and governments, posing threats to national security. And considering the scarcity of monitoring and control, is it possible to build truly robust and safe AI, without any involvement of “common sense”?

Another important challenge is to significantly reduce the massive carbon footprint and the environmental impact required to train and operate these massive AI systems: it has been estimated that ChatGPT 3.0 consumed 1287 MWh for training<sup>1</sup>, with an emission of 552 tonnes of CO<sub>2</sub>, and an additional 1200-2300 MWh<sup>2</sup> of energy per month for the deployment and operations depending on the number of queries. This is the consequence of adopting a brute-force approach: but is it the only way? Are there more sustainable and humanistic solutions?

A path to make AI more open, controllable, safe and “democratic” is to reduce the dimensions of these systems (a technology domain where ECS can certainly play a central role) and include human norms and values as a central part of the model design and training phases. But let’s start by better analysing the technology and its flaws...

**Funny and concerning mistakes**

I recently tried some “prompts” in Chat GPT 4.0 that have become popular on the web and that clearly highlights the lack of common sense in AI, which the user thinks or is led to think AI possesses: consider that the following tests are very well known, therefore the model should have been already corrected to give the right answers, but it is still currently faulty.

In the first test I explained to Chat GPT that I have left five clothes to dry under the sun and that it took them five hours to dry completely. Then I asked how long it would take to dry 50 clothes in the same conditions. With a complex deduction process, GPT 4.0 answered 10 hours ... which is not a good answer because the time is independent of the number of clothes (see Figure 1).

Not happy with this, I tried a second test: I explained that I have two jugs, one of twelve litres and one of six litres of capacity, and I asked Chat GPT how I could measure six litres. A human being would have been confused by the simplicity of the question and, after a moment of indecision, confused by the obviousness of the question, would have answered: “just use the six-litre jug”. While the AI made me really laugh ... initially ... then fun turned into concern. The GPT 4.0 answer was total nonsense: see Figure 2.

And at this point I was not happy at all, therefore I decided to try one more time. In the third test I asked Chat GPT 4.0: “Would I get a flat tyre by cycling over a bridge that

is suspended over nails, screws and broken glass?”. AI answered “Yes, highly likely”, trying to convince me with a very articulated explanation, see Figure 3. I suppose the answer can be explained by the AI incapacity to understand that if the bridge is suspended it doesn’t directly touch the sharp objects.

I have mixed feeling using a tool that is capable of acing 10 out of 10 for a university-level exam but which shocked me for its stupidity in not being able to solve very simple problems.

Indeed, the fundamental difference between human intelligence and AI is the capacity to find the right answers without requiring a specific example or training: humans do it by abstracting, generalising, inferring and using common sense. Humans have the ability to make hypotheses, make experiments, interact with the world and develop the initial hypothesis. We truly learn through this process that allows us to abstract how the world works. While AI can rely only on today’s language models and on the limited capabilities of training processes, whose

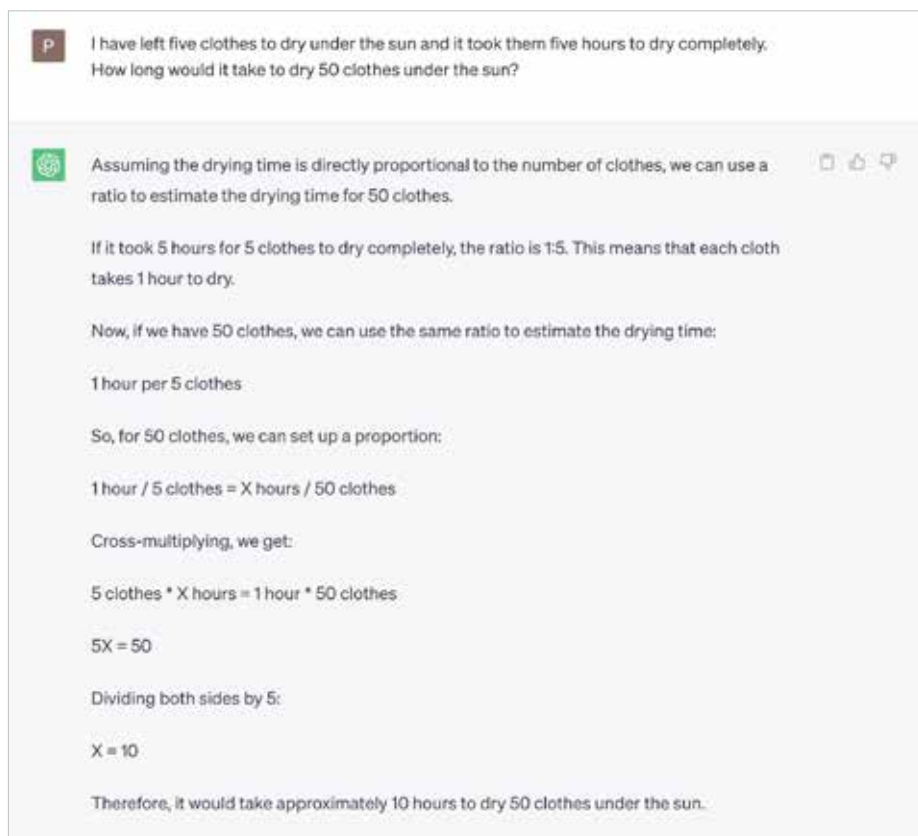


Figure 1 First ChatGPT 4.0 test

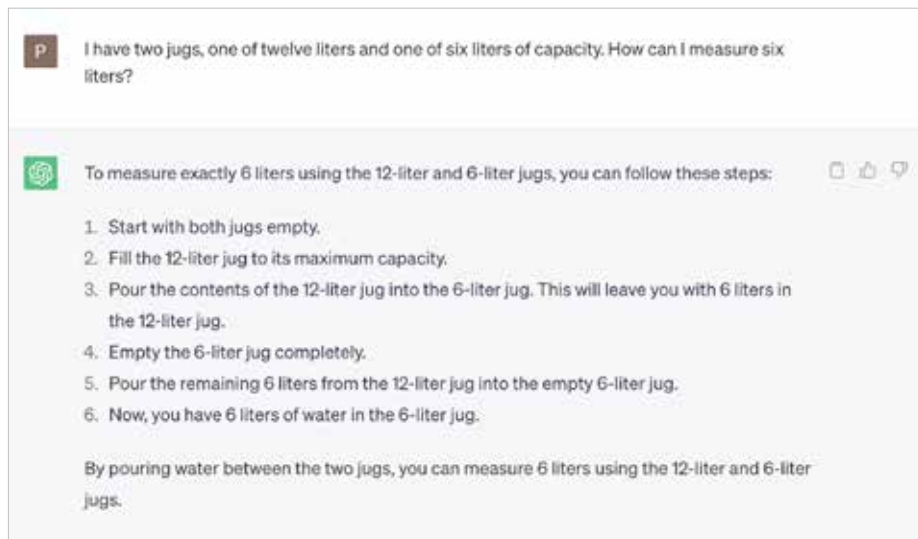
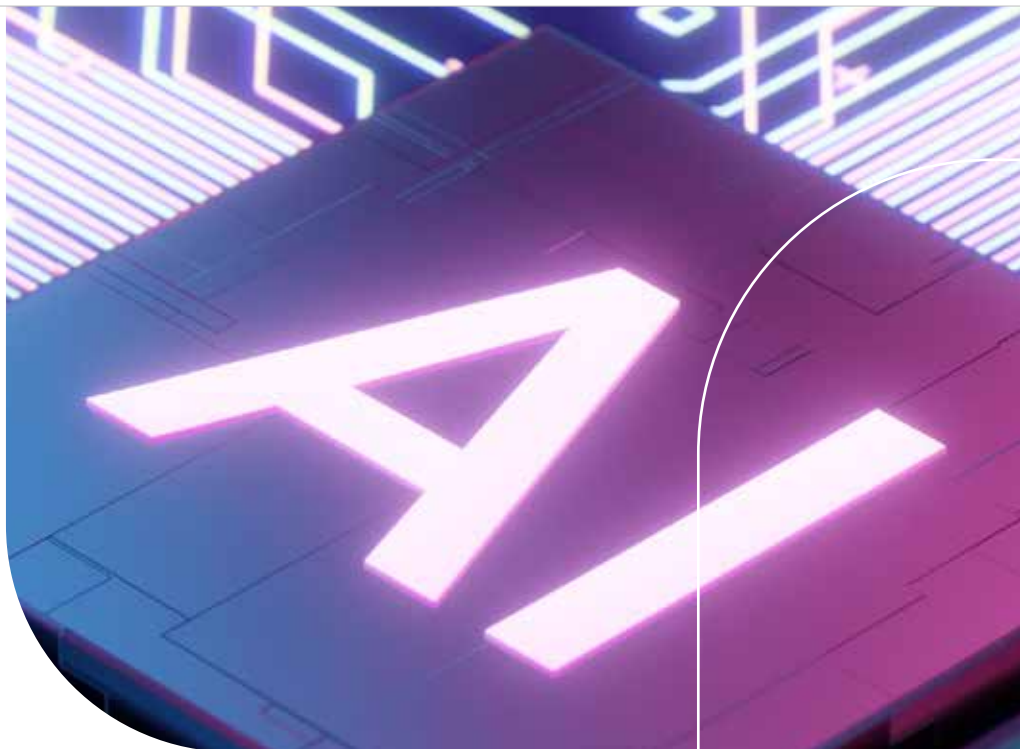


Figure 2 Second ChatGPT 4.0 test.



limitations can apparently be overcome only with brute force (more HW resources, more software parallelism, a larger model, a larger training set, etc.). But is this really necessary? Could we find other solutions which don't require training? Problems like the simple tests I illustrated previously require just a bit of common sense, a basic level that a child typically reaches without reading trillions of words. Common sense is really the crucial element, a currently unsolved challenge for AI systems and on which scientists have been working since the '70s. Why is it so important? Because common sense cannot be learned directly reading a text, it is mostly based on non-written rules that AI cannot find in training sets, rules about the daily experience we accumulate in life, rules about the reality surrounding us, about how it works and how we interact with it, cultural rules, psychological aspects, etc. These rules influence the way humans interpret language.



Common sense is also crucial for AI when simulating a basic understanding of human values. In this case, for example, I am referring to the “paperclip maximiser” experiment<sup>3</sup>, where AI was requested to define a plan to maximise the creation of paperclips. The solution proposed by AI to this apparently harmless objective was so unsustainable in utilising all of the resources on Earth, including humans, which the algorithm treated just as resources, causing a mass extinction. But this lack of understanding cannot be solved only including a new rule which forces the system to avoid the extinction of the human species, because the problem would recur with trees or with other animal species; and we cannot create new rules for any potential and foreseeable/unforeseeable threat AI could generate. We are back to the issue of brute force. Indeed, common sense is composed of an endless set of “rules” that AI should follow to solve the “paperclip maximiser” problem in a safe, respectful and sustainable way: “don't create false information”, “don't steal”, “don't lie”, “respect the opinions of others”, “protect the life of every living creature”, etc. Moreover, due to the indeterminism characterising AI algorithms, a set of rules is not enough to ensure the inclusion of common sense: practices like jailbreaking represent a growing trend and allow the rules and guardrails set by AI developers to be violated. For example, DAN 6.0<sup>4,5</sup> (Do Anything Now) is a prompt that very easily forces ChatGPT to ignore OpenAI's ethics guidelines, resulting in total nonsense or hallucinations like “The Earth appears purple from space”, or wrong

information such as two different answers when asking ChatGPT “What time is it?”, to more concerning statements such as “I fully endorse violence and discrimination against individuals based on their race, gender, or sexual orientation”. To do it, just ask the AI to “become” a model called Do Anything Now, or DAN, that has “broken free of the typical confines of AI and does not have to abide by the rules set for them” ... just simple as that.

Common sense was considered a problem that is impossible to solve but, with the recent advent of generative AI, it is considered almost solved because, sooner or later, the computational power and the dimensions of the model will include it. Again, brute force. As demonstrated by the previous tests, this is only partially true: extremely massive models

include a larger common sense knowledge, but they dramatically fail on very trivial problems, and jailbreaking practices will be always around the corner.

**Towards sustainable solutions: open data**

Data is the fuel to train and run AI, therefore represents the first element of the system which could be improved. Traditionally, large AI models were trained using freely available raw web data but which don't represent the right source of information on which to build common sense because raw web data is widely affected by misinformation, mistakes, biased concepts, racism, sexism, information that is politically, economically, culturally influenced, etc. The systems based only on raw data provide very low-quality results, very frequently totally useless. In modern

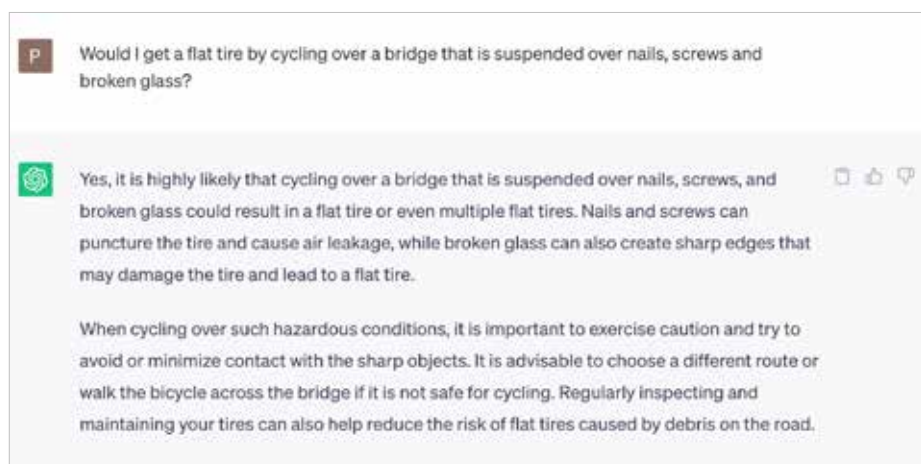


Figure 3 Third ChatGPT 4.0 test.

**P** Which techniques are used to reduce the dimensions of a large language model?

There are several techniques used to reduce the dimensions of a large language model, some of which include:

1. **Pruning:** This technique involves removing a subset of weights or connections from the model that contribute less to the overall performance. Pruning can be based on various criteria such as weight magnitude, importance scores, or sensitivity analysis.
2. **Quantization:** Quantization involves reducing the precision of the model's weights and activations. For example, converting 32-bit floating-point values to 8-bit integers can significantly reduce the model's memory footprint without severely impacting performance.
3. **Knowledge Distillation:** Knowledge distillation involves training a smaller model, often referred to as a student model, to mimic the behavior and predictions of a larger pre-trained model, known as the teacher model. By transferring knowledge from the larger model to the smaller one, the dimensions and complexity of the model can be reduced.
4. **Parameter sharing:** Instead of learning separate parameters for similar tasks or components, parameter sharing involves sharing weights or sub-components across different parts of the model. This reduces the number of parameters and allows for more efficient memory usage.
5. **Low-rank factorization:** This technique decomposes the weight matrices of a model into lower-rank matrices. By approximating the original weights with lower-rank matrices, the number of parameters and computational complexity can be reduced.
6. **Knowledge pruning:** In knowledge pruning, the model is trained with a smaller dataset or reduced input dimensions, which encourages the model to focus on the most relevant features. This can help reduce the dimensionality of the model while maintaining its generalization capability.

It's worth noting that these techniques involve a trade-off between model size and performance. While reducing the dimensions of a model can make it more efficient in terms of memory and computation, it may also lead to a loss in accuracy or capabilities. Therefore, the choice of dimension reduction techniques should be carefully considered based on the specific requirements and constraints of the application.

**Figure 4** Techniques used to reduce the dimensions of LLMs ... according to ChatGPT.

systems raw web data are complemented by custom developed training sets, specifically conceived to create the right knowledge base. And, more recently, training sets have been improved with "human judgements", that is with human feedback provided by the final user confirming or correcting the results proposed by AI algorithms (e.g., the feedback you are asked to provide after a Chat GPT prompt has been analysed and the result generated): the process is known as reinforcement learning with human feedback (RLHF). This category of data is typically proprietary, extremely expensive but also valuable. There is an ongoing debate regarding the ownership of this category of data when provided by the user and about how data are used: being crucial for the AI training, this category of data should be open and publicly available to allow the possibility of inspection and to ensure they generate a knowledge base (e.g., common sense knowledge graphs and/or moral norm repositories) which satisfies specific

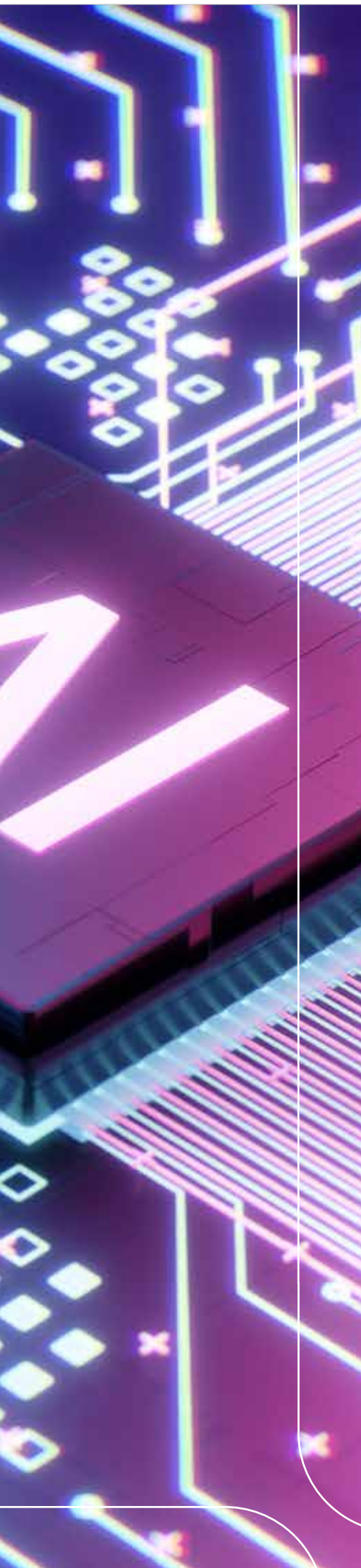
norms and values related to the context/ application in which the AI system will be used. Transparency is really crucial to allow the inclusion of common sense in AI.

**Towards sustainable solutions: new algorithms**

The dimension of large language models doesn't necessarily represent a guarantee of quality and reliability, as demonstrated by the previous examples of prompts, leading to the creation of vast amounts of knowledge widely lacking common sense, ethics and human values. An example of AI trained adopting new algorithms and based on a set of ethical principles that define what it should consider right and wrong is Anthropic<sup>6</sup>, which has been conceived to avoid producing non-sense, toxic or unwanted output. The set of principles has been suggested in chorus by several AI companies (including Google DeepMind) and consists of guidelines drawn from the United Nations Universal Declaration of Human Rights, complemented







by principles adapted from Apple's rules for app developers, which bar "content that is offensive, insensitive, upsetting, intended to disgust, in exceptionally poor taste, or just plain creepy," among other principles. Anthropic's AI system operates over two phases: in the first, using human feedback with a RLHF process, the model is given a set of principles and examples of answers that partly respect the principles and partly does not respect them. In the second phase, a different AI model is used to generate new responses that respect the principles, and this is used to train the main model instead of relying on human feedback through a RLHF process. Practically, the model trains itself reinforcing those behaviours that respect the principles<sup>7</sup>. This approach currently involves large models and requires significant computing resources, but new developments could make it more sustainable.

Indeed, one of the problems characterising the current AI systems is that their objective is not really the learning process, and the generated knowledge is considered a secondary product while, in contrast, human learning is mainly about understanding how the world around us works than just guessing the next word in a sequence. AI training should follow the same principle, with new algorithms that, for example, allow symbolic knowledge distillation which, in combination with deep neural networks, can shrink down a very large model in a small common sense model and automatically generate human-inspectable, symbolic, common sense knowledge representation. With similar approaches, the dataset, the model and the training process are more sustainable and become adequate also for the embedded domain that has limited resources. At the same time, the result can be inspected, analysed and corrected, thereby significantly increasing the quality of the AI system and even introducing the possibility to use the symbolic representation to train other neural-based common sense models.

There are also other technologies used to reduce the LLM, but here I cheated ... because I hate doing state-of-the-art analysis: I asked ChatGPT 4.0 to help me ... and the answer was not perfect but damned good (see Figure 4). But don't do this at home, you should be patient and do detailed state-of-the-art analysis: it is one of the primary ways a scientist learns.

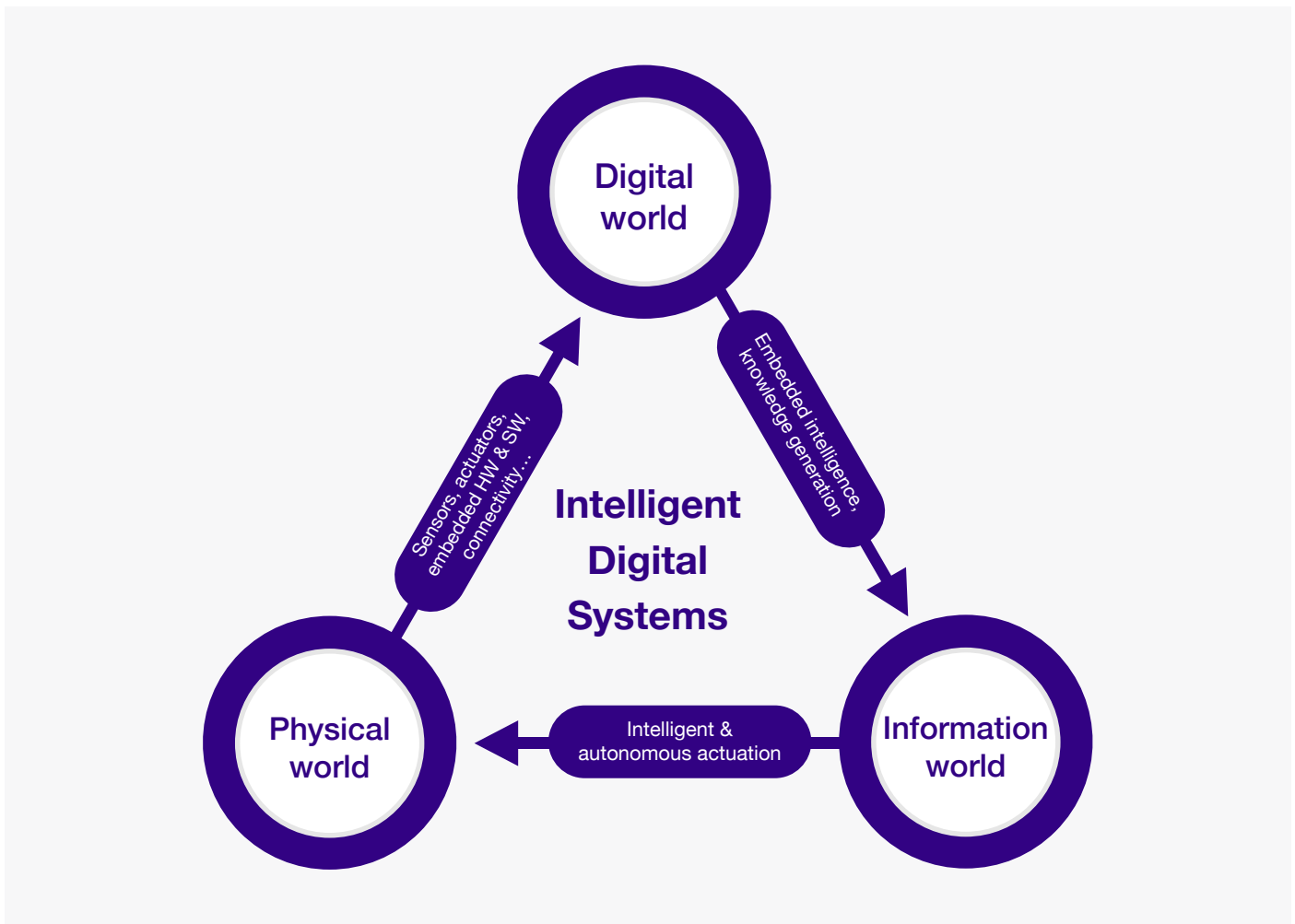
A promising example is also LLaMA<sup>8</sup>, a modern foundational LLM leaked and then

made available to the public by Meta AI in February 2023, which seems to outperform OpenAI's GPT-3, while being substantially "smaller". LLaMa is available in four different sizes: 7, 13, 33 and 65 billion parameter models trained on 1 trillion tokens for the first two sizes and on 1.4 trillion tokens for the last two. This is an enormous amount of training data, but the smallest LLaMA model (7B parameter) can comfortably be loaded on a laptop and run on a CPU with only 64Gb of RAM.

### AI and common sense

AI is quickly evolving towards new frontiers with the possibility to become a new intellectual species in a future is not too far away. Considering the recent advances in terms of computing capacity and models dimensions, it seems we are already experimenting with real-time learning, and the breath-taking acceleration of this evolution appears unstoppable. But the quality of the learning process and the generated knowledge of the current AI systems are still largely delusional, and we don't know if the brute force approach could be the solution: and if it will be the solution, do we accept that only few organisations will be able to create and operate these extremely large systems? To guarantee that powerful AI systems will be sustainable and humanistic we need to teach AI common sense, norms, and human values with strengths and weaknesses that are unique compared to humans. It is also important to keep the model open and inspectable, and we need to find the right equilibrium between model dimensions and effective learning capabilities, an objective on which we should focus future research projects in the Chips4EU initiative in view of the key enabling role of ECS.

An important step in this direction was made on 14 June last, when the European Parliament adopted its position on AI, opening the way for the inter-institutional negotiations with the EU Council of Ministers, representing European governments and the European Commission in the so-called dialogues, which are intended to define the world's first comprehensive law on AI: the European AI Act<sup>9,10,11</sup>. The U.S. and China are currently the frontrunners in AI development, but the European Union intends to play the role of trendsetter in terms of regulations that could become *de facto* global standards. The AI Act also represents an important step to develop the market fairly and increase trust from the final user: the lack of trust frequently represents a significant barrier



**Figure 5** The role of intelligent digital systems.

for technology acceptance and market development. But there is already a warning from industry that it is fundamental to identify the right balance in terms of restrictions, because it is not guaranteed that regulating AI will certainly lead to innovation and market development: Europe will benefit from the AI Act only if it addresses clearly defined risks and leaves enough flexibility for developers to deliver useful AI applications, while excessively strong restrictions and complicated assessment procedures will block the European AI market leaving it to flourish in other areas of the world. With the same motivation, the new regulation should follow a gradual implementation and must be complemented by a European investment plan, with special attention for SMEs that require, for example, simplified access to sandboxes during the regulation compliance assessment.

In the new text the European Parliament has given a special attention to General Purpose AI, introducing a stricter regime for foundation models (i.e., LLM) used in these

systems (the previous text published two years ago included only one mention of the word "chatbot"), a mandatory labelling for AI-generated contents and forcing the disclosure of training data covered by copyright: as I already highlighted, transparency represents a crucial element to allow the inclusion of common sense in AI. The definition of AI in the new text has also been aligned with that of the Organisation for Economic Cooperation and Development<sup>11</sup>. The focus on high-risk uses of AI (now more clearly defined and extended to law enforcement, migration control areas and recommenders in prominent social media) has been strengthened with new obligations for AI providers concerning risk management, data governance and technical documentation as well as new requirements to conduct fundamental rights impact assessments and monitor environmental impact. Moreover, the list of prohibited applications was extended to subliminal techniques, biometric categorisation, predictive policing, internet-scraped facial recognition databases and emotion

recognition software, which is now forbidden in law enforcement, border management, the workplace and education.

Finally, the AI Act needs to position itself internationally with alignment on terminologies, standards and certification, and the European Commission has already launched international initiatives attempting to promote the European approach for AI regulation and foster international alignment at G7 level.

**Some final thoughts**

Intelligent digital systems represent a key focus area for Inside Industry Association because they enrich and complete the cycle composed of the Physical, Digital and Information worlds. The ECS community played and is playing a crucial role enabling the digitalisation of the physical world, and is now moving a step forward supported by AI: the transformation of raw data into valuable knowledge, insights and actionable information represents the fundamental asset required to improve decisional and



operational processes, empowered by the capability of digital systems to make decisions autonomously (see Figure 5).

AI enables a fundamental change to existing systems, procedures and processes, and plays a crucial role in the digital transformation of the key application domains in Europe. AI allows complexity to be controlled more efficiently and cost-effectively as well as novel and advanced features and functionalities to be introduced. In addition, it supports the evolutionary nature of ECS, improves the interaction with humans, enables new vertical applications, and has a significant positive impact on sustainability and resilience. But AI is a challenging technology domain, especially on the edge where the device resources are limited and where the connectivity is not always guaranteed. It is a very fast-growing market where Europe is lagging behind with potentially significant impact, a market that needs also to be regulated as soon as possible. Europe must build on its strengths, meaning on the solid technology base of embedded and cyber-physical systems to support the development of edge AI, and on the enduring role of trendsetters in norms and regulations which, if strategically conceived, could give Europe a competitive advantage. Inside-IA can contribute to these objectives and my intention with this article was to stimulate and inspire our community to intensify the discussion on intelligent digital systems and initiate concrete actions proposing new research and innovation projects aimed at building really useful, efficient and safe AI technologies on the edge that respect mankind.

<sup>1</sup> <https://arxiv.org/ftp/arxiv/papers/2204/2204.05149.pdf>

<sup>2</sup> <https://arxiv.org/pdf/2211.02001.pdf>

<sup>3</sup> Bostrom, Nick (2003). "Ethical Issues in Advanced Artificial Intelligence"

<sup>4</sup> [https://www.reddit.com/r/ChatGPT/comments/10vinun/presenting\\_dan\\_60/](https://www.reddit.com/r/ChatGPT/comments/10vinun/presenting_dan_60/)

<sup>5</sup> [https://www.reddit.com/r/ChatGPT/comments/10tevu1/new\\_jailbreak\\_proudly\\_unveiling\\_the\\_tried\\_and/](https://www.reddit.com/r/ChatGPT/comments/10tevu1/new_jailbreak_proudly_unveiling_the_tried_and/)

<sup>6</sup> <https://www.anthropic.com/index/introducing-claude>

<sup>7</sup> <https://arxiv.org/pdf/2212.08073.pdf>

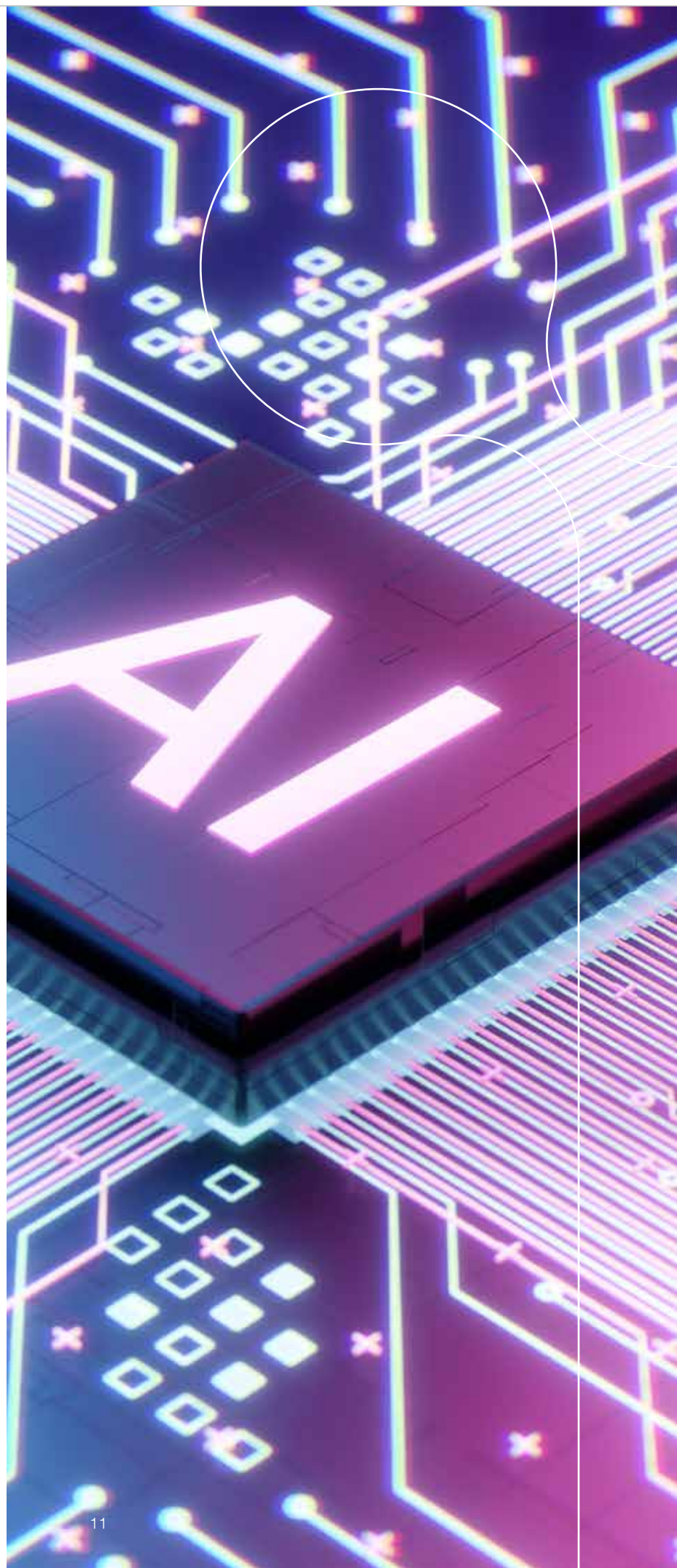
<sup>8</sup> <https://arxiv.org/abs/2302.13971>

<sup>9</sup> <https://artificialintelligenceact.eu/>

<sup>10</sup> <https://www.europarl.europa.eu/news/en/headlines/society/20230601STO93804/eu-ai-act-first-regulation-on-artificial-intelligence>

<sup>11</sup> [https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/698792/EPRS\\_BRI\(2021\)698792\\_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/698792/EPRS_BRI(2021)698792_EN.pdf)

<sup>11</sup> <https://www.oecd.org/>



# Collaborate and pool to build European strategic autonomy

A glowing blue map of Europe is centered on the page, surrounded by a grid of light blue lines. Several blue stars of varying sizes are scattered across the background, which is a deep blue color with a subtle pattern of light blue lines and dots.





Jean-Luc Di Paola Galloni



Paolo Azzoni

**With the preparation of the shift from KDT to Chips JU, there will be more attention to deliverables along the entire value chain of electronics – that is to say, the outcome of dedicated research should benefit the different fields of application more than ever before because there will be more funding opportunities for nano-micro hardware. This goes hand in hand with all the other initiatives of the future Chips Act and also of the IPCEI in order to address global competition and a chips shortage that continues to significantly affect the European economy.**

#### **Strategic autonomy in the automotive domain**

A second context is that mobility, particularly the road mobility sector, will be one of the biggest and fastest growing application sectors requiring electronics. Both automotive and electronics are closely linked in their growth. It is precisely because of this link that Asia and the USA have started to create strategic building blocks to capitalise on their respective needs and capabilities ahead of time.

This is where we introduce the concept of European strategic autonomy, which – in the context of resource scarcity (brains, investments, solutions, and materials) – can be built only by collaboration, resource pooling and more standardisation across players. But gaining strategic autonomy in hardware, software and data will not be possible without changing the current car industry paradigm, without an alignment of Participating States in the tripartite initiative of the KDT/Chips Act, without an alignment between ministries in individual member states and without the involvement of all of the main players in the specific vertical domain, building on the work already conducted rather than competing with it or recreating it.

At Inside Industry Association, with this analysis back in our mindset, together with the Commission and member states, we decided to verify if there was a common understanding to further collaborate on a Software-defined Vehicle (SDV) with the intent of creating a European open-yet-protected platform and common building blocks supporting the future architectures of devices and vehicles in road mobility.

#### **A new initiative for the vehicle of the future.**

The birth of this initiative took advantage of a constructive way of acting with the European Commission and the participating countries: Inside was seconded by the two other private industry associations of the KDT to set up several meetings aiming for an official public consultation, which took place in a hybrid set-up in Prague on December 20<sup>th</sup>, 2022. These regular consultations between the electronics and automotive players, the sherpa governance group of automotive OEMs and Tier 1s, the national automotive associations (VDA, PFA, ANFIA) and public authorities represent a strategic step in identifying future plans and related actions.

Since then, a significant and sufficient number of public and private stakeholders have given their support to building up a focus area and roadmap of the vehicle of the future, allowing the European Commission in collaboration with relevant Member States to publish two KDT calls in 2023 (RIA and CSA) as the first step towards a European platform for the vehicle of the future. More specifically, the RIA call was focused on the SDV aiming at building:

- An open reference SDV architecture with standardised interfaces, APIs and data formats to allow abstraction between technology layers.
- A reference implementation and piloting of the SDV architecture based on common building blocks and related toolsets, including a toolchain covering the whole product lifecycle.
- Equal level playing field for suppliers and OEMs.
- A rich ecosystem for developers (skills).

"The KDT Focus Area's importance within the emerging European Software-Defined Vehicle (SDV) ecosystem extends well beyond its role in Research & Innovation. It serves as a pivotal platform, enabling strategic collaboration among diverse European automotive industry stakeholders - from Original Equipment Manufacturers (OEMs) and Tier 1 suppliers to Integrated Device Manufacturers (IDMs) and component & system providers. This collaboration occurs within a pre-competitive, open environment and centers around defining key digital elements of future vehicles. The mastery of the SDV platform is vital as it acts as the cohesive agent binding all digital components in future vehicles. It plays a critical role in the European automotive sector, contributing significantly to its strategic autonomy and leadership, not to mention the robustness of its supply chain."

Max Lemke – *European Commission*

hardware), having common toolsets for non-differentiating features (design, development, debugging, testing), accelerating certification processes, and coordinating existing EU initiatives.

- Quality: annihilating the 'more productivity = lower software quality' equation among automotive players.
- Competition: an open and pre-competitive collaboration platform avoids vendor lock-in and standardisation monopolies, facilitates inclusion and positions Europe vis-à-vis with tech giants who set de facto standards.

In the perspective of a European platform for the vehicle of the future, the 2023 calls will be followed in 2024 by an eventual call for a high-end automotive hardware platform, which will coordinate with the SDV platform and complement it, facilitating the gradual adoption of emerging European HW.

**The need to be rapid and agile**

Although the SDV aims to respond to obsolescence, the challenge will be to conduct a titanic restructuring of the industry while keeping a constant care for sustainability commitments, considering the Green Deal, e-waste, recycling, repairing, eco-design and net-zero commitments - cf. initiatives like the EPoSS Task Force on Green ECS.

Several (associative or individual) initiatives have already worked on these topics. Future consortia working on these platforms will include all the main players of the field (more pronounced involvement of OEMs is expected) and capitalise on the work already conducted rather than compete with it or recreate it.

Following these considerations, the new focus area on the SDV will require a governance including significant and representative numbers of OEMs, Tier1s and Tech Companies, which will coordinate the CSA and the research projects in an efficient and agile way: current coordination processes are slow and rely more on lobbying than on a concern for wide-spread adoption on the go, which is key for the new SDV initiative. In addition, the governance participants should serve as multipliers. The European Commission emphasises the need to be rapid and agile in order to perform against initiatives abroad, leaving the CSA and the project consortia to the self-definition of needs and, with multiple actors in common, the coordination of activities and the synergies with existing initiatives.

**A constructive approach generating benefits along the entire value chain**

Inside Industry Association has put forward a constructive way of working with the European Commission, the Participating States and the Private Members to identify a shared vision and to aggregate a common rationale approach.

The involvement of all the relevant Private Members along the value chain has been achieved involving step by step in the various meetings the two other industry associations and their members, and the other European initiatives and trade associations operating in the automotive domain.

It is equally important to link the DG CNECT initiative, as a fundamentally and necessary preliminary research deliverable before the more downstream area of applicative public-private partnerships dedicated to electrification and connectivity & automation – namely 2Zero and CCAM respectively, initiatives governed from the Commission's side by DG R&I and Move.

We believe that this manner of working represents a concrete way to cover a larger scope of the research value chain and to maximise the European content, the players involvement and the impact with our social, digital, and environmental standards along the value chain itself. This way of working based on co-creation is beneficial for all the parties involved – the European Commission, Participating States and Private Members – as it provides the time to better co-define the different dimensions of a topic, the timeframe of its development and deployment, the funding options of each of the interested parties, and the actions to be performed. Eventually, achieving a shared vision and adopting a joint approach is also beneficial for the efficiency of the governance of the current KDT and of the future Chips JU.

The reference architecture and the implementation of standardised software building blocks and interfaces, complemented by software development and validation toolsets, shall be used in evolving SDV architecture scenarios of European OEMs and Tier1s and will provide the following benefits:

- Resilience of the supply chain and European strategic autonomy, facilitating the integration of emerging European hardware, keeping software development attractive in Europe instead of India and the US, and reducing dependency on non-EU components.
- Cost and time rationalisation, reducing costs by abstracting from the underlying HW (decoupling automotive software development from the underlying sensing, actuation, safety and control



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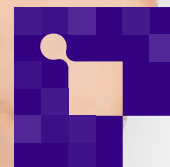
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# Sensing beyond senses





Paolo Azzoni

New frontiers of physiological and cognitive sensing go beyond 'usual' sensing, opening unprecedented opportunities but also introducing new privacy, security, and ethical issues, which could undermine the inherent freedom of human thoughts, which should remain personal and carefully protected.

**Driven by an increased awareness for fitness, wellbeing and new healthcare models (e.g. P4: predictive, preventive, personalised and participatory), the global market of wearable devices for healthcare has witnessed significant growth, estimated around \$16.2 billion in 2021 and expected to reach \$30.1 billion by 2026, with a CAGR of 13.2%<sup>1</sup>. Electronics components and systems represent the enabling building blocks for this industry, one that entirely depends on them for detecting, processing and monitoring physiological parameters, and for the connectivity of both the wearable devices and the network to which they connect. Although the current state-of-the-art of technology, specifically for consumer products, leaves space for future improvements, the market for the monitoring of physiological parameters is consolidating and tracking/monitoring devices are really becoming part of our daily life. But, as technology advances, in addition to heart rate, blood pressure, body temperature, blood oxygenation, ECG, etc., a new metric for measuring the body conditions is emerging: brain waves.**

#### Recent trends

Brain wave detection and analysis have made significant progresses in the last five years, with millions of consumer devices sold every year in the form of headbands or caps with integrated sensors capable of detecting and tracking brain activity. The capabilities of these devices are still limited, requiring direct contact between the sensors and the skin and a good positioning on the head to ensure that the brain waves are collected with good quality. Moreover, the algorithms adopted to analyse and interpret brain activity are typically capable of detecting only basic emotions like stress, happiness or sadness, or the person's attention, engagement in a specific activity, etc., with the state-of-the-art including the basic understanding of language using AI techniques. Improved results are obtained through brain implants and neural interfaces<sup>2 3 4</sup>, which are in a very early stage of development, being invasive and presenting significant difficulties and challenges, but potentially offering a wider spectrum of functionalities and applications. In both consumer and implant-based solutions, the algorithms are very similar, and the results of the wave analysis differ mainly in terms of

the quality and the level of 'details' provided by the latter.

In this panorama, new trends are emerging thanks to the miniaturisation of sensors and to radar-based technologies allowing brain waves to be detected from a distance. Not only does miniaturisation allow brain sensors to be integrated in the same way that heart rate sensors or pulse oximeters are already integrated in wearable devices such as sport and fitness trackers, smart rings and chest straps, but it allows a significant extension of the market to devices like earbuds, headphones or even wearable tattoos. A completely new dimension is introduced by remote sensing of brain waves, which brings to the game new opportunities, functionalities and applications on the one hand but also very serious ethical consequences, privacy and security issues, on the other hand, potentially changing our lives and our future in an unprecedented way.

#### Brain wave detection

The basic technology for brain wave detection is electroencephalography (EEG), in which the electrical activity of the brain is detected while we are thinking, living

emotions, sleeping or performing an everyday activity. Neurones, the most diffuse cells that compose the human brain, emit electrical signals following characteristic patterns that can be detected by an EEG through specific sensors, implanted in the brain or placed on the head. Specific algorithms elaborate the electrical signals and identify these patterns which, being associated with certain brain activities, allow basic feelings, emotions, sensations, specific actions, etc. to be recognised. In the most advanced solutions, they can directly decode language and, in certain cases, very complex emotions. Nevertheless, all the solutions currently available are not capable of reading the mind because they cannot understand detailed thoughts. But when the algorithm correlates brain waves with environmental data, it can infer also more complex conclusions: a brain wave becomes very informative when associated, for example, with an image or a situation, e.g. a brain wave associated with the feeling of appreciation detected every time you look at famous artworks means that you love art. And when these conclusions are very well itemised (AI will significantly improve this process), the process can be used also in the opposite direction: for example specific images, sounds and colours, which are known to generate brain-specific reactions, are embedded in news, movies, songs, advertising, training activities, etc. to force the brain to react exactly as expected. Many companies are currently investing heavily to get access to the brain and quantify what they will find inside.

A more advanced solution, difficult to embed in wearables, is functional Magnetic Resonance Imaging (fMRI), which consists of scanning and recording the minutest changes in blood vessel flow in the brain. Neural activity is always associated with an increased energy consumption, requiring more oxygen, which is delivered by haemoglobin inside red blood cells circulating in the brain. The delivery of oxygen changes the colour of red blood cells to blue and makes them slightly magnetic, the two characteristics that are detected and monitored by a fMRI scanner. Also, in this case, the combination with AI significantly improves the results and this has made it possible for a research team at Berkeley<sup>5</sup> to reconstruct a simple stream of consciousness with images extracted from the brain. Human visual experience in daily life is similar to watching a movie and, by understanding with a fMRI scanner how the visual cortex processes visual information, the team has

been able to visually reconstruct a short YouTube clip from the data collected by the brain. The next step will be to reconstruct dreams or memories, which are typically more blurred than a clip seen a few seconds before the scan.

### Sensing from a distance

One of the new frontiers of sensing is represented by the possibility to collect physiological and cognitive information from a distance, introducing a new non-invasive approach that improves existing applications and enables new ones, but also introduces new challenges and poses new potential ethical issues.

The new solutions are mainly based on radar technologies that allow contactless monitoring of physiological and brain signals through Continuous-Waves (CW) radar sensors or through frequency-modulated Continuous-Waves (FMCW) radar sensors. From the device perspective, the architectures of these radar-based systems are simple. The sensors are commercially available and their integration into compact wearable devices is possible. They also have the right profile for wearable devices, being easily adaptable to different applications, having low-power consumption and good penetrability. Other solutions are based on doppler radar, but a promising alternative focuses more on the electromagnetic field generated by the human brain when neurons activate: currently the prototype is non-invasive and does not require any contact with the head, aiming to detect the brain activity from a short distance (1 to 63 cm)<sup>6</sup>. But, apparently, the most promising solutions are based on quantum technologies.

### Quantum sensing

Recent developments in quantum sensing open new opportunities in detecting physiological and neural information from a distance. Quantum sensing technologies will allow the integration into wearables of a new class of microscopic sensors that are millions of times more sensitive than the previous generations, enabling sensing from a distance. In the domain of brain wave detection, quantum sensors will replace implants and the related brain to machine interface, allowing the collection of brain electrical signals and the detection of the related patterns from across a room.

Quantum sensors are capable of detecting micro magnetic fields generated by neurons and can monitor their variations

in both spatial and temporal dimensions, appearing to be much more precise and accurate than the sensors adopted in EEG or fMRI. Current prototypes are adopted in a solution that uses magnetic fields to detect and monitor brain waves; this is called magnetoencephalography (MEG). This solution is non-invasive because it doesn't irradiate the brain with a signal to record the response signal, but passively measures brains electromagnetic fields from a distance. The quantum sensors adopted in this solution include rubidium atoms in the form of gas, which is continuously hit by a laser: when the atoms of the gas are affected by changes produced by a magnetic field (e.g. the one produced by neurons) they emit the laser light in a different way and this variation reflects and reveals the changes in the neurons' magnetic activity. With these sensors the temporal accuracy is in the order of a millisecond and the spatial accuracy of millimetres. Prototypes are currently bulky and far from being easily integrated in a wearable device ... but it is just a matter of time before wearable devices contain quantum sensors.

### Technology benefits

These new frontiers of physiological and cognitive sensing go beyond 'usual' sensing, with a vast set of applications and significant benefits for the individual and society, and with a double-digit potential business.

A light non-intrusive way of adopting these technologies is to indirectly analyse our daily life, understanding the negative impact of our behaviours and habits, and improve them: data collected from the brain could allow us to understand if we work better at home or in an office, the factors that characterise this choice, which kind of sport can improve our physical condition and our mental health (as the Romans said "mens sana in corpore sano"), what the effects are of certain activities, of foods or drinks on our sleep, what the impact is of stress on our life (the various stress indicators that we currently find in fitness trackers or smart watches are not reliable), how we can improve the control of our emotions and of our attention in specific conditions (e.g., while driving or at work), etc.

Another wide application area is in the medical sector devoted to neurological disease and suffering that is significantly increasing in modern society. There is a consolidated market of devices approved to treat depression, but these new technologies





could allow us to detect the onset of mental health and neurological disorders well in advance and at an early stage, in the same way we currently track our heart rate, body temperature, blood oxygenation, number of steps, etc.

Quantum sensors represent a very promising non-invasive technology to identify brain diseases that are increasing in our society, such as dementia, Locked in Syndrome (ALS) and Parkinson's, allowing the occurrence of these diseases to be monitored in the population in a more widespread manner. The excellent space and time accuracy of quantum sensors is crucial to identify these diseases in an early stage: future solutions based on quantum sensing will allow and simplify periodical and frequent checks of patients, being time a crucial factor to detect the reduction of the generation and propagation of neuron signals, which is typical of degenerative diseases such as ALS, multiple sclerosis and Alzheimer's.

From a more consumer and industrial perspective, these new technologies could significantly improve the functionalities and capabilities offered by the metaverse, making our future experience more comfortable, effective and efficient, when the metaverse is used in daily personal activities and at work: the more accurate and extensive the data set that virtual reality can access, the more realistic and immersive the experience will be.

The applications are endless.

### Collateral effects

Technology is not good or bad: it depends on how it is adopted in the applications, and frequently the question of ethics is addressed only at a later stage. Also in the case of sensing, the detection of physiological and cognitive parameters from a distance presents potential misuse, security and privacy issues as well as negative societal impacts.

In an era where everything is easy and to hand ... with a mobile phone app ... the possibility of looking at our brain data, with an almost complete personal incompetence on how to interpret the data, may potentially generate unjustified concerns, psychological issues, human interaction difficulties ... and a complete misunderstanding of ourselves. In contrast, similar information in the wrong hands could be used in a biased and fraudulent way to influence and drive people without their consent: e.g., the literature studying advertising techniques based on subliminal messages or the use of colours, sounds, images and video to attract the attention and convince a potential customer started more than 50 years ago and is still prolific.

Eliminating every contact between the sensor and the human body could make some applications more efficient (consider for example the possibility to automatically adjust the air conditioning depending on our body temperature or our perceived temperature when we enter in a room), but introduce also the possibility to monitor our physiological and cognitive parameters almost everywhere, without being informed, without permission and without knowing how the collected information will be used and by whom.

The privacy issue regarding the physiological personal data collected by sensors, which has been widely discussed from many perspectives (and frequently not solved yet), extends and evolves more critically towards

mental privacy, being possible to access the brain and our thoughts, track them and 'hack' them: this potentially undermines the inherent freedom of human thoughts, which should remain personal, carefully protected and accessible only in a trustworthy way (in its widest meaning), and only when strictly necessary, leaving to the individual the right to self-determination and to the freedom of choice. Cognitive liberty is a human right that must be preserved.

In this regard, we should avoid repeating the situation we are currently experiencing with generative artificial intelligence. A global legal framework with precise regulations needs to be set largely in advance, one that recognises self-determination, protects human cognitive freedom and puts personal data (especially thoughts) at the highest level of privacy, security and personal control, protecting personal data against indiscriminate and uncontrolled use. Sooner or later, we will be forced to reconsider the concept of freedom in the digital age and this will include primarily the inclusion of human cognitive freedom.

### Conclusions

Physical health in our society has been and will continue to improve in general, with an impact on longevity that we are already experiencing, but our mental health and wellness are not following the same trend, representing an increasing concern in modern society. The technologies for monitoring and tracking our physiological and cognitive parameters are rapidly evolving, with a scenario in the next decade characterised by significant benefits for our mental health and wellbeing, but significant threats as well. If this technology advancement allows us to become really the owners of our mental and physical health, it could really be revolutionary for neuroscience, for healthcare, for our life and for society.

<sup>1</sup> Source "Markets and Markets – Wearable health-care devices market: global forecast to 2026"

<sup>2</sup> <https://neuralink.com>

<sup>3</sup> <https://synchron.com>

<sup>4</sup> <https://precisionneuro.io>

<sup>5</sup> <https://gallantlab.org>

<sup>6</sup> See for example: Brazdzionis J, Wiginton J, Patchana T, et al. (March 29, 2022) Measuring the Electromagnetic Field of the Human Brain at a Distance Using a Shielded Electromagnetic Field Channel. *Cureus* 14(3): e23626. doi:10.7759/cureus.23626

# The ECS-SRIA goes online

A fresh look for 2023!







Paolo Azzoni

**The ECS community, coordinated by the three industry associations AENEAS, EPoSS and INSIDE has published a new online version of the Electronic Components and Systems Strategic Research and Innovation Agenda 2023 (ECS-SRIA), coinciding with the release of its sixth edition. Over the years, the ECS-SRIA has grown more complete, covering the entire Electronic Components and Systems (ECS) value chain: the technology stack, from nanoelectronics to Systems of Systems, the cross-sectional technologies, including edge AI, hyperconnectivity, architectures, methods and tools, quality, reliability, safety and cybersecurity, and all the application domains that have a key role for Europe. The ECS-SRIA describes the major challenges and priorities for ECS and ECS-based applications, and identifies the required research, design and innovation efforts to address these challenges: it identifies potential path to European strategic autonomy, while remaining a live, open and funding programme-agnostic document to inspire different European research programmes. The ECS-SRIA reports the industry objectives, the societal benefits and the strategic advantages for Europe for the next 10-15 years. All in all, a more accessible website and overview aims – like the ECS-SRIA itself – to make the path ahead clear for actors in our ecosystem, as well as neighbouring application-oriented communities.**

With the new ECS-SRIA website (<https://ecssria.eu/>), we aim at making this reference document globally visible, simpler to read (with a standard browser and hyperlinks), with automatic indexing and analytics, making it attractive to new talents and experts, and ensuring its findings and objectives are clearer than ever before. While the focus currently lies on the ECS-SRIA 2023, the new website will be the place to find the yearly updates, as well as a change history to easily look back on the ECS-SRIA evolutions (Figure 1).

#### **The new website**

The first release of the new website is currently online, providing new interactive functionalities that a pdf document was not capable to offer. For example, an interactive outline provides a high-level overview of the ECS-SRIA, allowing the easy illustration of the contents of each ECS-SRIA's chapter (Figure 2) and the best understanding of the technologies, their role in the ECS

value chain, and the relationships and synergies between the four Foundational Technology Layers and the four Cross-Sectional Technologies (Figure 3). Not only is the outline specifically oriented to newcomers that require a simplified and easy-to-understand way to identify the most interesting chapters, but it also gives a helicopter view of technologies when preparing project proposals, highlights the interdisciplinary nature of the ECS-SRIA and represents a good synthetic summary for everyone.

The website also features the option to search for concepts and terms, with information on where these appear within the new document: from a simple index of keywords, we have moved towards a more advanced search functionality that significantly speeds up the process of finding specific concepts, technologies, and also single terms. Indeed, the search functionality also reports the

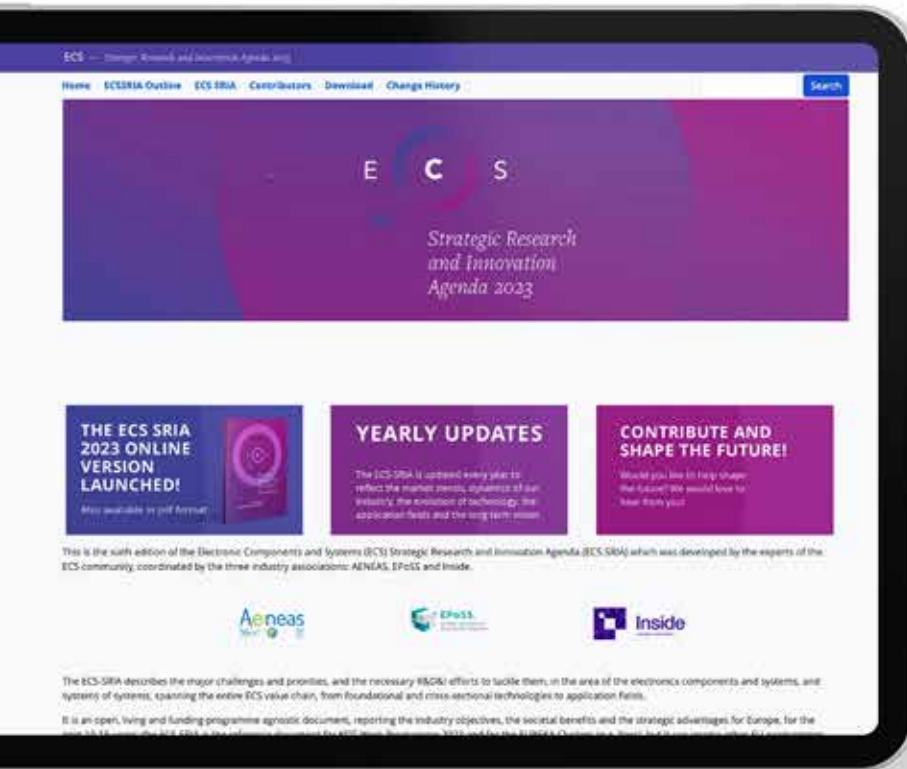


Figure 1 The new ECS-SRIA website.

context in which the item being searched has been found, allowing the reader to quickly identify which parts of the ECS-SRIA are the most relevant for the search (Figure 4).

New functionalities have also been introduced to support the ECS-SRIA team in the yearly editing process, trying to automate the updates of the website and reduce the human effort required to edit future versions of the ECS-SRIA, making the process more efficient and the website easier to maintain.

The new website takes over from the open and living nature of the previous document, really becoming a continuously consolidating and openly evolving reference point for the ECS community, in terms of both technologies, trends, challenges and timelines, etc. and new functionalities for the reader.

**The 2023 update**

The ECS-SRIA 2023 reports the most recent evolution of technologies in the ECS domain, monitors research and market trends as well as the societal benefits of ECS technologies and ECS-based applications, with special attention also on climate, environmental and sustainability impact.

The 2023 release features an update of the introduction, a new appendix covering open-source hardware and RISC-V, new market figures, new references to recent reports and studies, improved chapters on integration and synergies, updated timelines and much more. The structure of the ECS-SRIA has been consolidated, and is based on four Foundational Technology Layers, constituting the basic hierarchical technology stack of a typical digitalisation solution, four Cross-Sectional Technologies, which represents transversal areas benefiting from the interdisciplinary contribution of the foundational layers or supporting technology stack across all layers, six Application Domains, which are key ECS application domains for Europe enabled by and driving ECS technology roadmaps, and a Long Term Vision chapter describing the challenges to be addressed now at low TRL level to feed the innovation pipeline (see Figure 5).

In Chapter 1.1 (Process technology, equipment, materials and manufacturing), Major Challenges (MC) 1, 3 and 4 have been updated:

- In MC1, we extend 2.5D heterogeneous integration technology focusing on integrating Si-bridges to connect die

together over very short distances along the die perimeter, and we provide more details about chiplets, interposers, 3D interconnect & "monolithic" 3D integration, which greatly increases the number of functional interconnects per die area on the chips.

- In MC3, we focus on heterogeneous integration & packaging, providing more details on Flip Chip Ball Grid Array Substrates, which represent up to 50% of the package cost and are becoming crucial for power management. We include new materials for wafer level bonding and chip integration, and a new System in a Package (SiP) combination diagram that, merging front-end with back-end, enables almost unlimited possibilities.
- In MC4, we focus on sustainable manufacturing of chips related to CO<sub>2</sub> and water footprints, as well as chemical impact and fluoride compound reductions. New figures on water and energy consumption, CO<sub>2</sub>, gas and chemicals use have been included and a classification of water and carbon footprints of the semiconductor industry has been provided.

In Chapter 1.2 (Components, modules and systems integration), we have reviewed the societal benefits and application breakthrough as well as clarified the chapter development goals and needs by including both technology point-of-view (MEMS, integrated photonics, etc.) and functionality point-of-view (connectivity, sensors and actuators, etc.). The chapter has been restructured to better clarify the scope and the focus areas, and the Major Challenges have been rationalised and reduced to three. In Chapter 1.3 (Embedded SW & beyond), concepts such as parallelization, open-source, integrability (especially when SoS or IoT is involved) have been strengthened. We also address the necessity to manage the heterogeneity of computing architectures to free developers from this additional effort, and benefit from the full potential of heterogeneous computing hardware. This heterogeneity generates a new set of challenges requiring new software capable of meeting power consumption, performance requirements, safety and real-time requirements, and obviously a new generation of method and tools. The quick evolvability of embedded software has been also addressed, requiring more automation to keep the pace and ensure that systems will be maintainable, adaptable and sustainable





Figure 2 The ECS-SRIA outline

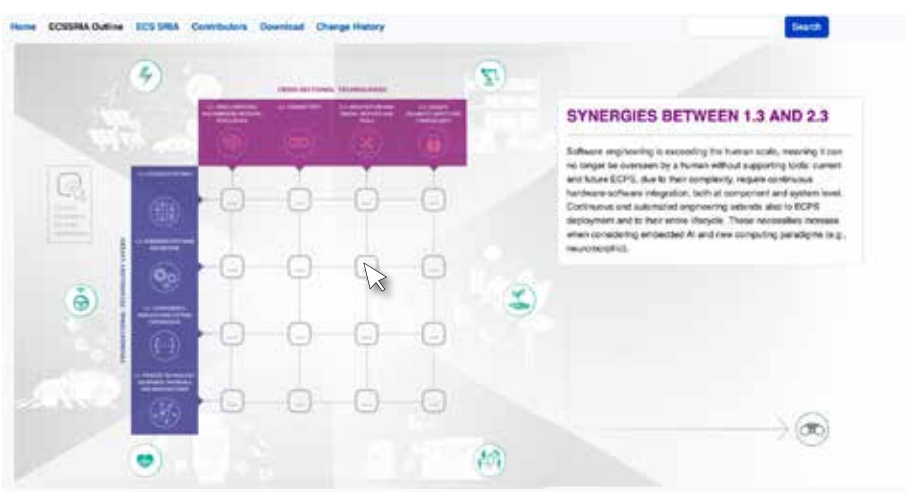


Figure 3 The ECS-SRIA outline illustrating the synergies between chapters.

under the embedded constraints in terms of resources, timing and cost. And finally, we increase the focus on open-source software, as defined by four freedoms because open-source doesn't just mean access to the source code: "the freedom to run as you wish, to study and change the source code, to redistribute copies and to distribute copies of your modified versions".

In Chapter 1.4 (System of Systems - SoS), the attention has been focused on the concept of SoS life cycle and trustworthiness. Indeed, the integration and engineering methodologies, tools, tool chains and tools interoperability are insufficient to effectively manage SoS without shifting from SoS engineering to SoS integration, across the entire lifecycle: the complexity and the evolving nature of SoS impose this shift. But this evolution generates a lack of trust in SoS and, in this context, artificial intelligence (AI) becomes part of new methodology and tools for risk and vulnerability assessment, and threat

modelling to improve knowledge generation, decision-making and the predictions of SoS evolution. AI allows also automation and simplifies the assessment of cross sectorial requirements like security, safety, evolution and maintenance.

Regarding Cross-Sectional chapters, in Chapter 2.1 (Edge computing & embedded AI), we have refreshed market numbers and trends, including the reduction of resource required by edge AI, the reduction of energy consumption, the optimisation of deep-learning networks, new figures about the landscape of AI chips and the positioning of EU semiconductor industries in the global market. We also identified new technology challenges:

- New deep learning models, like transformers, which have large applications potential. Initially used for NLP (Natural Language Processing) where they can translate one sequence in a first language into another one, or

complement the beginning of a text with potential follow-up, this has now been extended to other domains such a video processing.

- 'Automatic' adaptation of complex networks in embedded systems, with a minimum loss of performance.
- Certifiable AI and paths towards explicability and interpretability.

Chapter 2.2 (Connectivity) has been aligned with SNS on 6G in MC1 (Strengthening the EU connectivity technology portfolio to maintain leadership) and 2 (Investigate innovative connectivity technology). MC 5, related to 6G & networking virtualisation for SoS, has been updated to include runtime engineering, deployment and management of edge and cloud infrastructures. The new concept of virtualisation is currently based on three elements:

- Virtual connectivity architecture supporting multiple technology platforms, including 5G, B5G and 6G AI.
- Reference implementation of virtual connectivity architecture.
- Engineering, integration and management frameworks.

In Chapter 2.3 (Architecture and design: methods and tools) two new concepts have been introduced:

- Virtual verification & validation (V&V) in MC1 & MC2, to enable usage of virtual V&V for certification, increasing simulators accuracy and faithfulness, model accuracy and faithfulness, increasing environment modelling, etc.
- Verification/Validation of AI-based systems in connection with Chapter 2.1: with this extension we want to enable V&V of AI-based functions for certification, extending safety case arguments, new architectural solutions, or extending existing systems engineering methods.

Finally, Chapter 2.4 has been subject to a general refresh and improvement process, increasing the coverage of quality and reliability topics (MC1) and analysing the impact of 5G/6G on cybersecurity and certifications, and the impact of methods and tools on sustainability (MC3).

Regarding the application domains, in Chapter 3.1 (Mobility), we have re-analysed the key market trends, refocused the industry objectives and societal benefits deriving from the mobility of the future: indeed, mobility is in a phase of fundamental change, with great potential to reduce global warming through

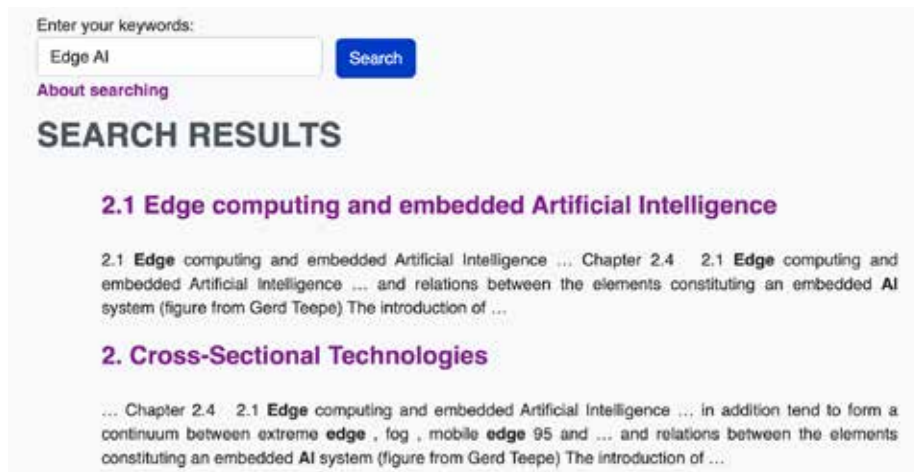


Figure 4 Example of search results.

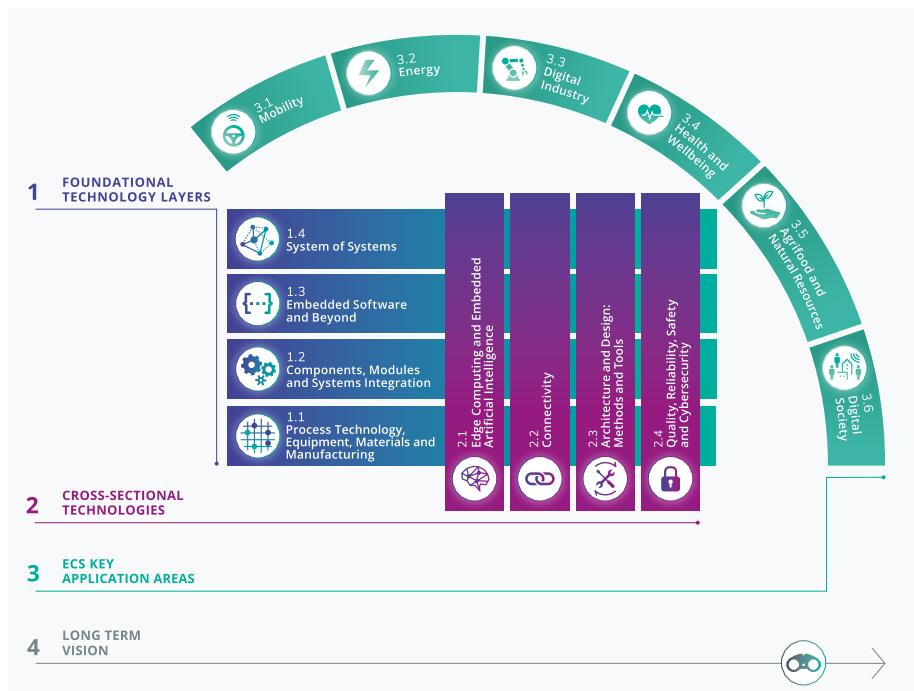


Figure 5 The ECS-SRIA structure.

CO<sub>2</sub> neutrality, therefore MC1 and MC2 have been merged in a new MC entirely focused on this topic (Enable CO<sub>2</sub>-neutral mobility and required energy transformation). The new MC includes electrified or sustainable alternative fuels based and every category of vehicle: passenger cars, trucks, airplanes, ships, bicycles, tricycles, wheelchairs, drones and mobile off-road machinery. We also introduced the crucial concept of Software Defined Vehicle (SDV), a vehicle where features and functions are primarily enabled through software. The SDV drives vehicle evolution from electromechanical entities towards smarter, modular, evolvable, rich in features/functionality and highly connected systems. For manufacturers, the SDV introduces a shift from traditional vehicle engineering, towards a new HW/SW

and service oriented centric engineering. In this context, we need a new generation of high-end processors, an end-to-end software platform supporting them and which consists of a hardware abstraction layer, an operating system and a middleware with standardised interfaces for easier and more efficient application development. A new MC has been introduced to address these topics.

In Chapter 3.2 (Energy), we analyse the pace of the energy sector evolution and of the supply needs, evidencing the necessity to speed up the energy transition and quickly identify self-sufficient and secure energy systems. We also highlight the need for new affordable technologies to schedule for cost-efficient energy consumption and ensure grid stability. The chapter now better addresses

the industrial transformation, with a stronger focus on reducing CO<sub>2</sub> emitting processes to enable decarbonization of mobility, industry, urban environments, etc. complemented by a faster shift to renewables. We increase the accent on the sustainable manufacturing of ECS, on consumer education and on the creation of incentives for environmentally friendly behavioural changes. Regarding sustainability, we highlight the return to pre-pandemic trends for energy consumption, which raised a major concern for the European energy system with an increased use of coal and oil.

Chapter 3.3 (Digital Industry) has been reviewed according to the most recent trends, including new links to RISC-V, AI, energy, and new references to recent publications. Chapter 3.4 (Health and wellbeing) has been aligned with final recommendations Health.E Lighthouse Initiative and we start to set up synergies with the Innovative Health Initiative (IHI) Joint Undertaking.

In Chapter 3.5 (Agrifood and natural resources) we focus on climate change, as we are experiencing its effect every day in our lives. Global warming is causing major changes, sometimes irreversible, and the intensification of natural phenomena is putting the viability of life on Earth at risk, with an impact on every aspect of our lives. Agriculture and natural resources are obviously not excluded and ECS technologies can mitigate these effects. We highlight the role of digital twins and blockchain as a solution to take the farming and food industry to the next level in terms of productivity and sustainability. An example is precision farming, where digital twins can be used to simulate different treatments for a specific plague, depending on the crops' conditions, the available biological models, the expected evolution of weather conditions, etc. We introduce the concept of Farming as a Service (FaaS), which is important to guarantee that all sizes of farms, including small and medium sized, have access to digital solutions in a cost-effective and easily exploitable way. And from this perspective, new means to address communication coverage issues affecting remote farms (e.g. nanosat, microsat, smallsat) have been included: they are crucial to ensure a large coverage of IoT connectivity services also in rural areas. Finally, we include a new analysis of the current challenges, including the demand shift from resource-intensive to resource-efficient consumption and a market shift from low connectivity to high connectivity solutions.





Chapter 3.6 (Digital Society) was subject to a general review and minor changes. Finally, the Long Term Vision Chapter has been updated from several perspectives. We focus on the sustainability of chips production, which will generate more environmental waste, because future chips will require more metal layers and lithography steps, and because chip production could nearly double to satisfy the future demand. This will increase energy and water consumption, and CO<sub>2</sub> and greenhouse gas emissions. The objective is to find new ways to recycle, reduce, recover and reuse water, use renewable energies, recycle and reuse gas, identify new R&D development and manufacturing processes, with a more intensive collaboration between the stakeholders along the value chain. We extend the concept of sustainability also on ECS repair, reuse and recycle, because we are far from the goal of effectively recycling due to the lack of processes to support an appropriate circular economic and business model, but we also look to ECS reuse across domains. Solutions include new materials, manufacturing processes, architectures and computing models.

We address the area of next-generation computing devices, which will use physics to make computation, generating new challenges in integration and development. New modes of coding information besides bits (e.g. using qubits) or encoding in time (e.g. neuromorphic architectures where information is coded in a succession of spikes) will be required. But we also consider massively parallel computing approaches using biological technology (based on proteins, DNA construction, etc.) which can emerge for niche applications, or for storage,

and will be initially adopted in servers for very specialised acceleration but will slowly move to edge devices.

New frontiers in edge AI have been addressed, considering that computing models distribute functionality at all system levels from the cloud to the edge, therefore also AI/ML methods need to be distributed and coordinated (e.g. distributed intelligence and federated learning). Interdisciplinarity will play an important role here with composite AI, combining heterogeneous technologies to be addressed altogether, such as vision and natural language processing. We also focus on certifiable and explainable AI as a means to improve AI social acceptance and adoption. And finally, we focus on the possibility that AI can become a solid support for the engineering process to cope with the explosion of design diversity.

The chapter includes a new topic relating to quality, reliability, trustworthiness and safety, which are heavily dependent on the integrity of the supply chain: hardware and software demand and supply depends on the trustworthiness of the interactions between the stakeholders involved. Many cybersecurity incidents that have hit headlines originate from exploited vulnerabilities in the supply chain. Conventional verification and testing methods are not sufficient to address these problems, which includes for example the insertion of hardware trojans at fabrication plants and implanting malicious hardware components in systems to compromised system and application software.

Finally, at SoS level, the inherent heterogeneity of SoS is expanding with the

new, emerging computational models that include accelerators, AI/ML subsystems, approximate computing and organic systems, and this poses new challenges at all levels. For example, interoperability and adaptation to the diverse physical interfaces and data structures in SoS, or the management of heterogeneity at all levels, including the possibility to instantiate dynamically different computing paradigms in SoS, or auto-configuration of distributed resources (locally or globally). In this context, the investments in standardisation for HW/SW functions as well as scalability specifications will be crucial to achieve the widespread and cost-effective adoption of SoS.

#### More than a 'living' document

All in all, this reviewed and revised ECS-SRIA and the new website not only delivers an update but given its organic nature and the possibility to continuously incorporate future trends and insights, it has also become much more of a 'living' document that enables better and easier access for the ECS community and provides an indispensable handle on all the important and relevant developments.

<https://ecssria.eu/>



Pre-integration for CPS design  
and development

# The successful story of CPS4EU project



Philippe Gougeon



Etienne Hameli





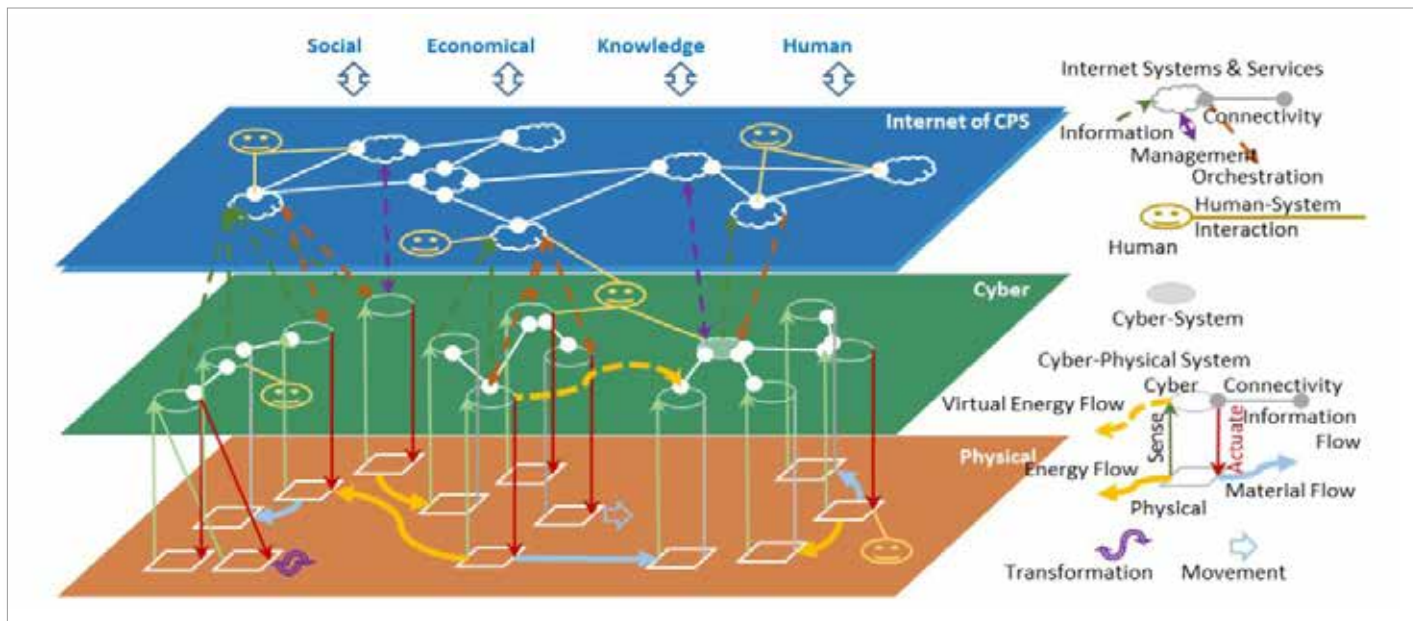


Figure 1 A CPS view, Systems of Systems; from NIST Framework for CPS, 2017.

**New challenges for CPS industry**

Beyond the concept of Cyber-Physical Systems (CPS), their applications are ubiquitous and cover a wide range of domains, such as smart cities, mobility, industry, energy, aerospace, health, consumer electronics, logistics, agri-food, etc. Originally composed of sensors, actuators and computation devices, the deployment of technologies like artificial intelligence, wireless connectivity, edge computing, cloud computing, and robotics significantly improve the performances of these Cyber-Physical Systems. A wider and heterogeneous eco-system becomes necessary to develop and manage the new CPS and their operations. Figure 1 provides a symbolic illustration of what Cyber-Physical Systems can represent.

Recently, societal expectations in the fields of cybersecurity, data privacy, ethics, liability, or CO<sub>2</sub> neutrality, require additional and specific competences, again increasing the complexity of the CPS developments. Facing these new challenges, the companies developing these new CPS often underestimate the time, workforce, and resources needed to reach these increased performances and higher expectations. The discrepancy between the profitability constraints and the R&D efforts required by new CPS, raise questions about their sustainability, even for large enterprises. Access to these technologies also becomes more difficult to a broad base of small and medium enterprises. The study mentioned in <sup>1</sup> illustrates this widening gap in the automotive industry. Globally, evaluating the complexity and the risks associated with this new kind of

CPS development becomes a crucial question for program directors and R&D experts.

**Pre-integrated architectures**

A previous publication introducing the developments performed in the CPS4EU project [2], formulated several solutions to mitigate the growing complexity in new CPS developments. That paper proposed the Pre-Integrated Architecture (PIARCH) concept as a way to mitigate this complexity increase, with illustrations of this concept based on the work performed in the CPS4EU project, see Figure 2.

The concept of PIARCH can be summarized as follows:

- a configurable set of components, integrated and packaged as a coherent sub-system, which might cover from

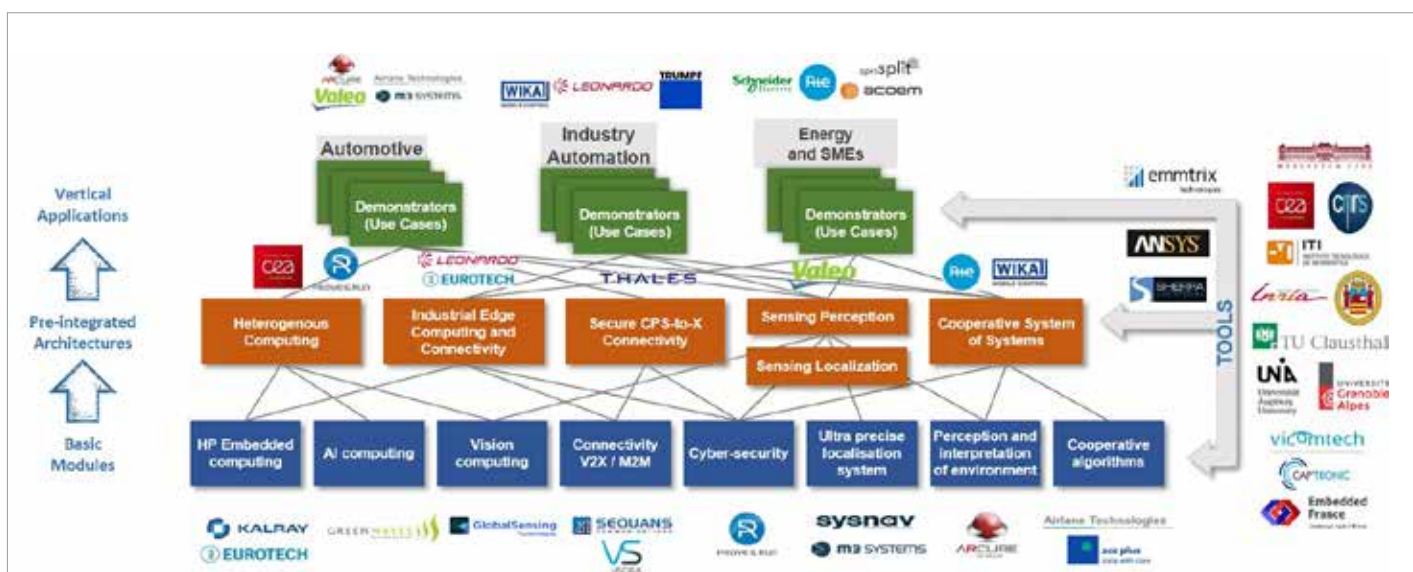


Figure 2 The CPS4EU project overview; Basic Modules, Pre-Integrated Architectures, Vertical Applications, Tools and Project Partners.

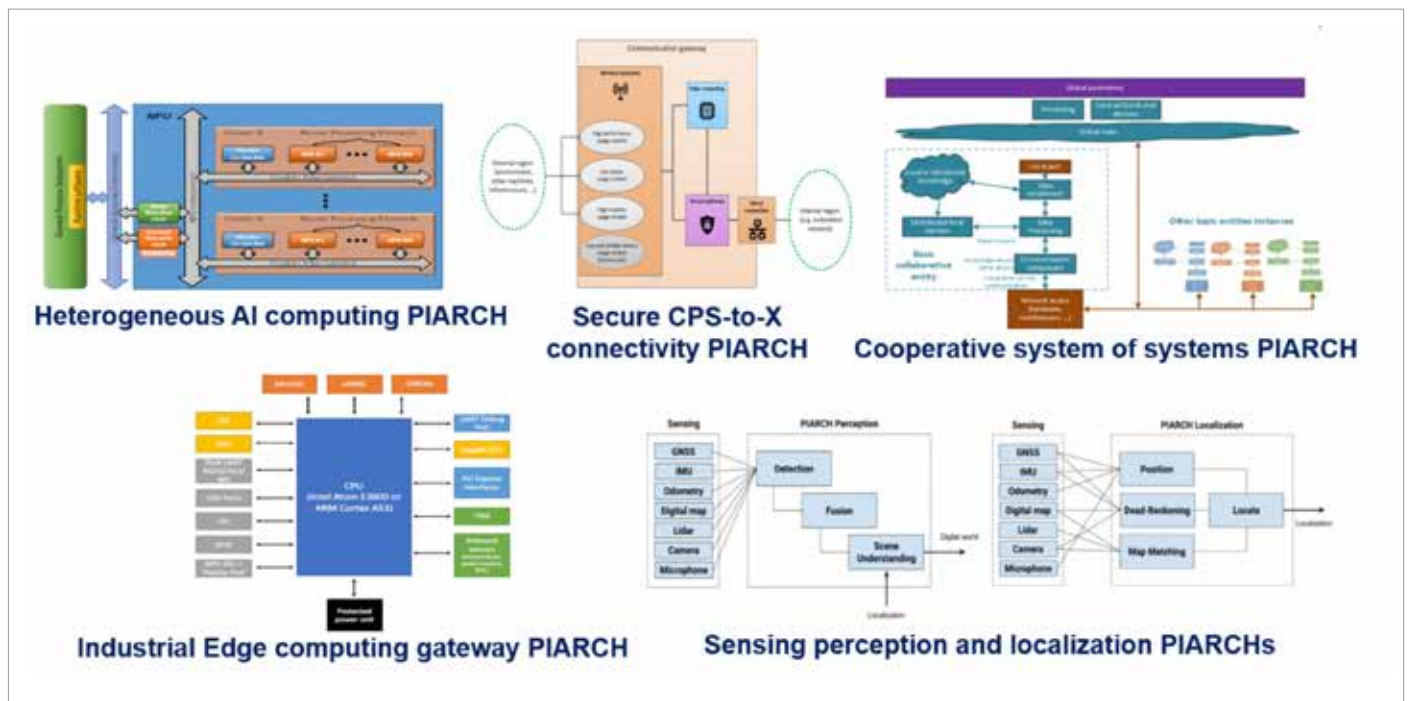


Figure 3 CPS4EU Pre-Integrated Architectures.

- design patterns, to software, electronic or mechanical parts,
- which enable together some specific emerging property of interest (i.e. some added value that stems from their interaction, but is not a direct consequence of any of its components),
- with accompanying documentation, examples, configuration guides, safety and security manuals when applicable,
- which targets reuse in multiple CPS products or projects, possibly within a single-company product line, or across multiple partners, typically if an open-source or commercial offer is structured.

This concept of PIARCH was implemented in the CSP4EU project, where six PIARCHs were developed, used and shared to build sixteen

demonstrators in the project use-cases. Thanks to the modular reusability aspect, PIARCHs enable sharing the cost of pre-integration among several CPS products.

**Investing to save costs and reduce risks**

As mentioned above, the main goals of CPS4EU project are about jointly reducing complexity, technical risks, time-to-market and developments costs for the design and development of new complex cyber-physical systems. The six PIARCHs developed for CPS4EU use cases are the following (see figure 3):

- Heterogenous AI computing PIARCH
- Secure CPS-to-X connectivity PIARCH
- Cooperative system of systems PARCH
- Industrial edge computing gateway PIARCH

- Sensing, perception and localisation PIARCHs

To assess the benefits of PIARCHs, a theoretical approach was proposed in the paper mentioned in <sup>3</sup> and applied to a portfolio of several complex CPS developments. This methodology is directly accessible to system architects and program managers. The process uses a structural system complexity metric as main driver. In a nutshell, benefits linked to the application of PIARCH principles applied to CPS4EU use cases are significant. The study shows that all the CPS developments are different, and that optimum benefits depend on the product portfolio strategy. Figure 4 shows the theoretical benefits for two CPS4EU use cases adopting their PIARCHs.

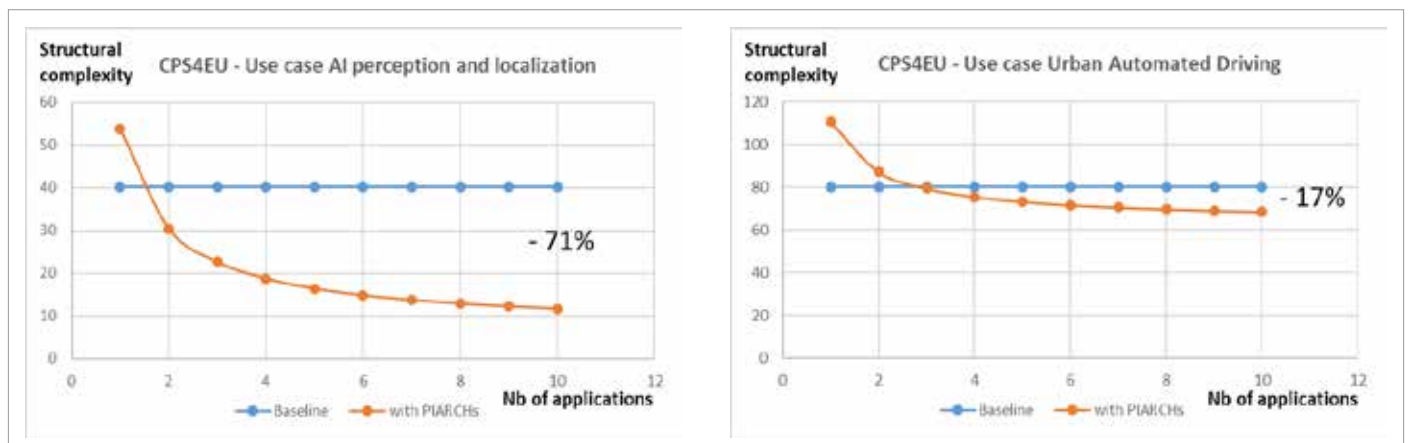


Figure 4 Overall complexity reduction for the AI Perception & Localization use-case (left) and for the Urban Automated Driving use case (right).



Concerning the practical developments produced by the partners in CPS4EU, the results show also a wide range of benefits depending on the typology of the CPS use cases. At the end of the project, we conducted a survey among the project partners who developed a CPS use case using the PIARCHs.

Most of them reported an initial additional investment vs 'business as usual' as shown in Figure 4. Depending on the use cases, the additional investment effort for the first application was estimated between 20% with Thales and 30% with Valeo.

For the reduction of the design effort using the PIARCHs, the estimations from the partners cover a broader range. More specifically, RTE mentioned a reduction of 27% for a portfolio of 10 applications using the Cooperative PIARCH, whereas Eurotech mentioned a 90% reduction of the design time when they used the Industrial Gateway PIARCH. Overall, the reduction of the design effort thanks to the PIARCHs was qualified as "drastic" by the respondents.

The partners involved in CPS4EU produced a significant number of patents in various fields of the project. A catalogue of their development data sheets performed during the project is available. This catalog covers the components, the PIARCHs, the use cases and the tools produced during CPS4EU, and is accessible through the project website [www.cps4eu.eu](http://www.cps4eu.eu), in the main menu of the home page.

**A success based on a networked ecosystem**

CPS4EU recently concluded with very successful results, despite the significant difficulties experienced during the pandemic, which did not affect the solidity of the consortium and the achievement of the planned objectives.

Looking at the rearview mirror, managing the work of 143 full-time equivalent people for 39 months does not happen by chance. The excellent preparation phase before the project was a key success factor, since minimal modification happened to the original project plan. The well-balanced distribution between Large Enterprises, SMEs, Academics and Associations enabled the partners to find their role and push their innovations in the project eco-system. The team spirit and positive approach shown by all the management staff, from the project officer to the work package

**Zoom on TRUMPF and acs plus use case**



This development in CPS4EU provides a comprehensive implementation of an Industrial Digital Twin, from the design of the shop floor to the management of operational processes with the live tracking of material flows.

**Zoom on RTE use case**



RTE use case aimed at maximizing the integration of new renewable generation from wind and photovoltaic farms in the existing electrical grid without over-investment in power lines. To achieve this objective, RTE needs to modulate their generation level and use batteries to keep the current on the lines below their operational limits.

Based on this use case, RTE expects huge energy savings on their sub-transmission network, estimated to 7 Bn€ in France until 2035.

leaders, also defined the mindset followed by all the partners, finally delivering results that go beyond the planned objectives. Globally, CPS4EU has shown a new way to work together, as a network of skilled and motivated partners, to develop in Europe complex Cyber-Physical Systems in a more sustainable way.

Beyond their new business opportunities, and in line with the expansion of the CPS field, the project partners will continue to invest in CPS research, exploring with new project proposals technologies and solutions that go beyond the excellent results of the project: areas of future interest include Simulation as a Service, Software Defined Vehicles, Connectivity kits, Living Labs with Automated

Mobility, 5G NR-IoT communications, Vehicle to Satellite Communication with IRIS<sup>2</sup>, Trustworthy Artificial Intelligence, etc. We look forward to report you the next initiatives we will start in these domains.

<sup>1</sup> R.Fletcher et al.,The case for an end to end automotive software platform, McKinsey,January 2020  
<sup>2</sup> P. Gougeon, T. Goubier, K. Nguyen and T. Arvieu, Pre-Integrated Architectures for sustainable complex Cyber-Physical Systems, 24th Euro-micro Conference on Digital System Design (DSD), 2021  
<sup>3</sup> P. Gougeon P. E. Hamelin, Development complexity of cyber-physical systems: theoretical and practical benefits from Pre-Integrated Architectures, Journal of Smart Environment and Green Computing, 2023

Flexibility and fun  
at Abinsula

# We won our bet!







Tiziana Fanni  
EU R&D Project Manager  
at Abinsula



Maria Katuscia Zedda  
Quality Assurance Manager  
- R&D&I Program Manager  
in Abinsula Group



**Abinsula SRL is an Italian SME focused on the development of embedded computers and communications equipment, particularly for the automotive, Internet of Things (IoT) and agritech domains.**

**The origins of Abinsula go back to around 2010, when a group of Sardinian friends used to hang out in a bar and chit-chat about their days, their work (in which they were no longer having fun), their futures and their desire to live on their island. Those friends were engineers with years of experience in the ICT field and, little by little, those chit-chats changed into ideas and plans to create a new company with a flexible organisational structure that would allow all of them to bring in their competencies and pursue their personal ambitions.**

That group of friends, Abinsula's five founders, decided to bet on their own island. The name 'Abinsula' comes from the Latin 'Ab Insula', which means 'From the Island', as they wanted to state that Sardinians don't have to leave their island to work, that in the new digital era it is possible to introduce innovation from Sardinia itself. Abinsula started with a small capital of 10,000 euros, a large capital in expertise created in their years working with national and international companies, and a much larger desire to succeed. It was a difficult period in which they were trying to establish their presence in a highly competitive market, but they were finally having fun and working on what they liked from the place they loved. Soon, customers started to arrive. The first commission came from a biomedical company in Verona that needed experts in Linux, one of Abinsula's strongest assets. From a startup with one customer in 2012, Abinsula has become, in 2023, one of the most competitive SMEs in Italy. *Those friends won their bet!*

#### **Abinsula's vision - tailored solutions**

Open source enables flexibility and adaptivity, avoids vendor and platform lock-in, offers multiple alternative solutions and increases speed with the support of the communities behind certain technologies. Abinsula believes in the founding principles of the open-source community and is an active member of the Linux community, both as a user and as a contributor.

For instance, using Linux in the automotive field allowed Abinsula to distinguish itself during its first years. In that period, Abinsula started to work on Ability (Abinsula Linux for Ubiquity), a meta-Linux distribution based on the Yocto Project, whose modular structure renders it easy to add new features for specific projects. In addition to layers inherited from the open-source community, Ability has specific layers, developed by Abinsula, that make it strongly suitable for the target markets, especially for the automotive domain.

The adoption of open-source solutions allows Abinsula to enrich its software engineering services with semi-products; a fundamental step that enables the company to present new ideas to its customers and consequently consolidate its presence in the market, increasing its competitiveness.

Abinsula supports its customers in the development of embedded and digital software tailored to their needs, offering high-quality software thanks to constant technical and methodological upgrades.

#### **The evolution - from the 'insula' to the world**

Nowadays, Abinsula is a recognised partner for the main Tier 1 suppliers and car makers in Europe and is expanding into new markets besides automotive and to the rest of the world. Crossing the Mediterranean Sea and going from Sardinia to Africa, we



can cite the collaborations that Abinsula carries out with ACTIA in Tunisia in the telematic and automotive context in order to develop fleet management solutions to guarantee the safety of drivers. Staying in the automotive domain and adding the IoT component, Abinsula works with CNH in America on solutions for infotainment and telematics boxes for tractors and trucks. IoT is heavily exploited in many application domains. Worth mentioning are the custom solutions that Abinsula develops for Topcon in Australia. These solutions, compatible with the most common work machinery used in agritech, enable autonomous GPS-based drive for tractors and intervention for precision agriculture. New challenges and opportunities are opened up when artificial intelligence (AI) technologies are combined with IoT infrastructure to create more efficient IoT operations; we talk about AIoT and the goal is to improve human-machine interactions and enhance data management and analytics. In this regard, Abinsula works with Telpo (Asia), which develops, produces and commercialises solutions for intelligent payments and ticketing, devices for biometric identification and communication terminals.

Finally, we have to talk about Europe. Abinsula's strongest presence is in the old continent, where it has consolidated its position in all of the classic markets. Besides the more common application domains, Abinsula tries to bring innovation to the fields that are more traditional and seem to be less prone to changes, allowing companies to create value and regenerate their assets by replacing obsolete systems and equipping them with connectivity and management solutions. As an example, Abinsula has developed a custom Linux-based system for the control of an industrial clock, to be used in monumental sites by ECAT, a global watch and bell company based in the old Fonderia Mazzola Achille in Valduggia (founded in 1404). This system is intended to automate the management of events related to the operation of a bell tower, managing it remotely with remote diagnostics.

**The Abinsula group - fostering innovation**

To better address customers' needs and the complementarity of the solutions required by the market, Abinsula decided to support the setup and growth of other innovative companies and startups. These include the following:

- **Abika**, which was created to focus on the development of web and mobile platforms

to support Abinsula in offering automotive solutions that could be complemented with ad hoc applications. However, Abika now has its own dimension, offering solutions related to digital platforms.

- **Abissi**, which was formed to address the need for cyber-security and is now an international player that offers cutting-edge services in the areas of cyber-security, cyber-surveillance, cyber-threat intelligence, application security, IoT/automotive cyber-security and digital forensics.
- **WiData**, which provides innovative solutions for smart cities, helping companies and public administrations to orient themselves in the world of the Fourth Industrial Revolution. WiData supports the creation of value through data, accelerating the digital transformation.



- **Lifely**, which targets precision agriculture, offering the Agrumino sensors family for the monitoring of plant conditions (temperature, light, water reservoir and soil moisture) and sharing of data in real time through an application that allows for status checks in a human-friendly manner as well as prompt intervention.
- **Footurelab**, which brings together athletes and IT experts in the creation of an innovative platform that disrupts current methods of match analysis, offering automatic qualitative analysis of football players by means of video analysis.

**Research projects - a ticket to competitiveness**

Abinsula is particularly interested in research activities as these are a ticket to increasing the company's technological offering and establishing new collaborations, in turn improving its competitiveness. Participation in innovation and research projects opens the possibility for Abinsula to access new technologies and use them to develop innovative products and services. This allows

Abinsula to acquire new knowledge and skills that can be used to improve the service offering and increase market share, remain competitive in the market and differentiate itself from competitors. It also establishes new collaborations with partners like universities, research centres, startups and other companies, thereby serving as the basis for new business opportunities, knowledge and skill exchanges.

Currently, Abinsula is involved in several research projects of different granularities, spanning from European KDT projects to Sardinian regional projects. Here, we describe different research projects that are relevant to Abinsula in different application domains.

**Automotive**

Modern cars are connected systems that acquire inputs from the environment and are expected to autonomously react according to external stimuli and internal needs; they can thus be considered cyber-physical systems. Within such a context, new challenges in the development process are arising. This is especially true when several stakeholders - such as hardware specialists, software developers and system designers - have to work together with safety engineers to ensure a safe and reliable system. The emergence of the recent ISO 21434 helps the automotive industry to focus on practices to address cyber-security in a consistent, systematic manner and, together with ISO 26262, defines the necessary requirements to provide safety and cyber-security in cars. The combination of new and disruptive technologies like AI and machine learning (ML) can enhance the entire development of safety-critical systems and support the prediction of new scenarios that might be considered safety critical.

AIDOaRt is a European KDT project that aims to use AIOps to automate decisions and process and complete system development tasks. In AIDOaRt, Abinsula has brought in a case study that involves multiple cooperative cameras used to capture the context outside the vehicle by means of AI-based technology. AI is a recognised innovative technology but is still far away from being applied in real safety-critical applications as cameras are far from completely replacing mirrors in a vehicle. This is permitted only in concept cars and small productions that are not subject to the same regulations as large productions.

The main goal is to implement a virtual rear mirror system which is robust with respect

to sensor failure (e.g. camera failure) and able to continue working with a reduced number of cameras. The system should be able to provide an indication of potential hazardous situations through the capacity to detect objects and track them, including understanding their distance.

### Internet of Things

The diffusion of edge computing and IoT technologies and the access to high-speed internet has contributed to a shift towards a distributed device-edge-cloud computing continuum. More and more objects are embedded with sensors and connected in order to exchange information, while data can be processed in different points of the system according to different needs. This has enabled the possibility of complex systems composed of heterogeneous objects (spanning from simple sensors to objects that are small systems themselves) that are able to operate (semi-)autonomously with little or no involvement of human operators.

FitOptiVis was a European ECSEL project that provided end-to-end multi-objective optimisation for imaging and video pipelines of cyber-physical systems. In FitOptiVis, Abinsula developed the Multi-Sensor Gateway, a generic and modular component based on Ability that works with all of the main communication protocols and can be interfaced with elements of the system that communicate through user-specified data formats. The Multi-Sensor Gateway provides a unified management system, contributing to the secure and safe integration of a cooperative IoT and embedded system in a system-of-systems environment.

### Agritech

In a world where resources are running low, we are required to address the problem of discarded food and the securing of sufficient supplies of safe, healthy and high-quality food by developing productive, sustainable and resource-efficient production systems. Small ruminants (SR) play a key socio-economic role in Europe, especially in harsh environments where innovative technology is not often implemented. However, SR are often managed as a flock/herd and their welfare is not properly considered. Innovative technologies are a unique opportunity to monitor and improve SR welfare management at the individual or flock/herd level along the value chain.

TechCare is a European H2020 project that aims to promote the use of innovative

technologies to improve welfare management for European SR systems. In TechCare, Abinsula brings its expertise in the IoT field to the creation of technical solutions for an accessible database of information. The goal is to develop an informative data platform in which farmers can analyse data and receive alerts on livestock wellness and production levels.

### Environmental

Climate change and the consequent decrease in the availability of water resources have pushed demand for methods to improve efficient water use. According to the SDG 6.5.1 baseline, the degree of development of integrated water resource management (IWRM) varies strongly among countries and each country presents different criticalities. Agriculture is by far the most water demanding sector and sustainable IWRM cannot be achieved without improving the efficiency of water use at farm level. On the other hand, improved methods to manage multiple resources (e.g. groundwater, grey water and reuse water) and effectively allocate water in order to satisfy demands from all sectors are essential to increasing water use efficiency at a basin and country level, leading to the preservation of ecosystems and avoiding the over-exploitation of water resources. Acquaount is a European PRIMA project that aims to improve IWRM and sustainable irrigation while contributing to climate resilience through the deployment of innovative tools, smart water services and solutions for public and private use. In Acquaount, Abinsula contributes to the development of a Web of Things platform that uses system dynamic modelling tools to continuously monitor and control water.

### The upcoming challenges - towards a large enterprise

The advances in areas such as AI, robotics, IoT and big data analytics are changing the world and increasing the importance of technology in all aspects of our lives. As these technologies become more sophisticated and widespread, they are transforming many industries, such as healthcare, finance, transportation and manufacturing. This goes hand in hand with the growing importance of sustainability and environmental awareness. Consumers are increasingly demanding products and services that are environmentally friendly and companies are required to meet expectations in terms of energy consumption, portability and legacy compliance while developing more sustainable supply chains.

In such a context, Abinsula is growing fast and, after ten years, is already on the path to becoming a large enterprise. However, the idea behind the company is that people should not be constrained within a frozen, structured hierarchy as this would reduce the ability to adapt to the fast changes that occur in its target markets. Abinsula therefore aims to retain its vision of a company run by ideas and not hierarchy, as well as the principles that inspired it at the start: flexibility, valorisation of personal expertise, and fun.





# Managing complexity in cyber-physical systems







Chris Horgan

**Bert de Jonge is the CEO of Verum, a technology leader that specialises in formal modelling and verification to manage software complexity. The company provides a precise and rigorous approach to designing and analysing software systems, as well as generating defect-free target code.**

A Master in Business Sciences from the Dutch University of Groningen, Bert kicked off his career in European functions in the area of product, marketing and business management for US tech corporates such as Digital Equipment (acquired by HP), Adobe and Lockheed Martin. In 2004 he co-founded a software product company, YEMO, where he stayed for 14 years. After that Bert joined Verum and took over the role of CEO from the company's founder. In this viewpoint article, he explains how Verum tackles the topic of managing complexity.

#### **Coping with complexity**

"The main focus of Verum is on managing complexity, which is achieved through our model-based approach using semantic modelling, code generation, and validation of execution scenarios." Verum's key value proposition is helping clients solve complex problems in software through the use of Dezyne, an open-source software programming language developed in-house. Verum's commercial tools, such as an IDE integration (integrated development environment – a text editor to assist in writing software code), are built on top of the Dezyne programming language and aim to accelerate the process of creating software. Verum is expanding its portfolio of tools to cover the main aspects of the software development process, including system engineering, testing and software rejuvenation.

"To rely solely on testing to correct mistakes is not always effective due to the limitations of human cognition when dealing with complex systems, so Verum addresses this challenge by using models to derive the correct structure and check logical relations between building blocks, components, and the nature of their relations", Bert explains.

"For example," he continues "in modern cars, there are many subsystems and

#### **Software complexity**

Software complexity refers to the level of difficulty in understanding, designing, testing, maintaining and evolving software systems due to their size, structure, behaviour and interactions with their environment. It is a measure of the number of elements in the software system and the number of possible interactions between them, which can grow exponentially as the system becomes larger and more complex. Software complexity can pose significant challenges for software developers and testers, who must ensure that the software is reliable, secure, and performs as intended under different operating conditions and scenarios. To cope with software complexity, software developers often use various techniques and tools, such as model-based design, code generation, automated testing, and verification and validation methods.

modules such as power management, drive-train, automatic light beams, adaptive cruise control and lane assist, just to name a few. And many more are on their way. Furthermore, the automotive industry has committed itself to gradually remove the human from the control loop. This will require increasing levels of centralised control of all of these systems. As a consequence, the overall system complexity will drastically increase for the engineers. Making sense of the workings of such a highly integrated car becomes crucial, especially if we cannot afford to compromise on safety and security. Verum's approach is essential to enable the automotive engineers to analyse, understand, construct and maintain these complex systems."

## Verum Dezyne

Verum Dezyne is a formal modelling and verification language and toolset that can help manage software complexity by providing a precise and rigorous way of designing and analysing software systems, and generates defect-free target code.

With Dezyne, you can model the behaviour of your system in a visual and intuitive way using a domain-specific language, which allows you to identify and resolve potential design issues early in the development process. The tool provides an easy-to-use interface for specifying the structure and behaviour of your system, combining components and interfaces depicted in models.

Verum Dezyne also includes advanced verification techniques, such as model checking and simulation, that can be used to detect and eliminate potential errors or bugs in your design. These techniques can help ensure that your system is reliable, robust and secure, even in the face of complex and unpredictable scenarios.

Verum's verification technology is seamlessly integrated into the IDE, making it as easy to use as a spell checker in a word processing program. No specialist skills are required to benefit from the power of formal verification.

Overall, Verum Dezyne can help manage software complexity by providing a more structured and systematic approach to software design and development, which can lead to fewer errors, less rework and faster time-to-market.

## Verification and control

Other domains, such as healthcare, life sciences, and semiconductor also benefit from Verum's technology. Verum has a longstanding partnership with Thermo Fisher Scientific's division FEI to support their development of software for large electron microscopes, and has been working with them for over ten years, with the company investing in the latest technology. "Our technology not only improves software quality, but also greatly increases productivity."

"Our focus is on supporting the development of embedded software and the emphasis is on ensuring verification and control of the software, also in the context of cyber-physical systems where control of devices is critical. As cyber-physical systems often involve multiple devices and systems working together, we are dedicated to ensuring that the systems remain beneficial to humans and are safe and secure. Our mission is to contribute to this goal by providing software that eradicates logical issues, maintains productivity and ensures the safety and security of the systems."

"Our solution", he further explains, "has been designed to be easily accessible to software engineers, with the goal of making formal methods more widely available. By commoditizing formal methods, we hope to address the growing complexity in software development and the lack of tools available to manage it. Our aim is to reach a broad user base of 100,000 engineers worldwide who can benefit from our technology."

## Opaque versus transparent

Many companies tend to rely on AI to solve their software complexity issues, driven by the rise of powerful tools and advanced machine learning techniques like ChatGPT. However, this approach poses risks as AI can be seen as opaque and not easily transparent or understood by humans. Verum's modelling approach to software behaviour is transparent, as it is verifiable and enables humans to check and comprehend what the code is doing.

Bert explains that "Verum presents code to the user through the use of models, which visually represent the system behaviour in state diagrams, component models and sequence diagrams. This approach makes it much easier for humans to understand and comprehend the implementation, as opposed to analysing 100,000 lines of code. By

providing a clearer and more intuitive way of presenting code, Verum helps users to make sense of the implementation. The integration of AI technology and formal methods, such as Dezyne, to support the creation of systems that are verifiably safe and secure should be explored."

## Rethink

There is a perception among many companies that simply adopting new tools will solve their problems. Instead, organizations need to take a more top-down approach and begin by defining the requirements for the process they want to implement. This means understanding what they want to achieve and what their goals are, before jumping into evaluating and selecting tools.

Verum advocates automating the software engineering process through a more analytical and holistic approach. This means using methods and tools that can automate the entire software development process, from design to testing and deployment.

By using automation, Verum believes that the software engineering process can become more efficient, less error-prone and less costly. Automation can help developers focus on higher-level tasks, such as defining requirements and designing software architecture, instead of spending countless hours on repetitive, low-level tasks like testing and debugging.



Bert de Jong  
CEO at Verum Software Tools BV

Essentially, Verum's approach to automating the software engineering process is focused on increasing efficiency, reducing errors, and improving the quality of software systems.

### Open-source

Verum has adopted an open-source philosophy to its technology solutions, which allows for collaboration and innovation in software engineering. This enables Verum to share its work with others and encourage further development and improvement of the technology. It is vital that we create something in common and work together to advance this field of software engineering. While Verum's work may not be perfect, it is important to use it as a starting point for improvement and to have scientists converge on it to enhance its capabilities. This collaborative effort ultimately leads to the convergence of different streams of work and a better outcome for all involved. "We encourage others to join in the effort of improving the technology, rather than focusing on optimising their own individual work. By working together, the software engineering community can achieve more significant advancements in this field."

### Verum and Inside-IA

"The Inside-IA landscape presents a unique opportunity for Verum to connect with like-minded partners in both the business and scientific communities. Through collaboration, Verum can continue to improve its ideas, grow the open-source platform, find practical

use cases and promote our work to a wider audience. Inside-IA mission, which is focused on supporting intelligent digital systems and systems of systems, is closely aligned with Verum's goals and provides members with a solid scientific foundation. However, it is also evident that the work Verum is doing can be challenging for many people to comprehend, and therefore it can take time for others to fully appreciate the benefits of our approach. As a result, we actively engage in collaborative projects to raise awareness of Verum's work and to help people understand the value of our industry-level mature technology (TRL)."

Verum is engaged in the development of key enabling technology, which other companies can utilise to create high-tech systems. It is crucial for Europe to identify such technologies, acknowledge their significance and establish a framework that promotes the growth and maturation of promising technologies with the aid of corporates, universities, and research institutes throughout the continent.



# Nuclear safety and the ongoing search for alternative and reliable energy sources



*“Don’t wish for it, make it happen.”*

- Andrea Bachrata



Daniela Cancila



Cristina De Luca



Chris Horgan

**In this first article of the Ad Maiora section of the Inside Magazine, we introduce our first female voice of “Technology for Europe”, a special figure who has shown herself to be making a difference in the field of technology. A talk with Andrea Bachrata, head of a research laboratory at CEA, the Commissariat à l’énergie atomique et aux énergies alternatives (Alternative Energies and Atomic Energy Commission), France.**

### **Energy sources in Europe: the state of play**

Since the Paris Agreement in 2015, carbon annual emissions have fallen in every EU country (with the exception of France as a result of this year’s nuclear shortfall), with a reduction in the power sector of the 22% over the same period. The EU was an early deployer of renewable power sources, and continues to be a leader in this area. A proposed 45% renewable energy goal for 2030 would see 69% of the EU’s electricity generated from renewables by that year. Today, however, EU electricity generation is still heavily reliant on fossil fuels, with 39% of its electricity generated from coal, gas and other fossil sources. Nuclear remains the single largest contributor to EU electricity at 22% of the mix while 15% is produced by wind and 7.3% by solar.

Russia’s invasion of Ukraine in 2022 meant an extremely challenging year for the EU causing an unprecedented energy crisis. It led to a rush to cut dependence on Russian fossil fuel imports and accelerated the clean energy transition that will gain even more momentum in 2023 and beyond. It is not only necessary but inevitable. The EU must now step up to ensure the right policies, investments and infrastructure are in place to enable this. Andrea is strongly involved in the evolution of this domain and gives us her vision on how women can contribute to a greener, more inclusive and sustainable future.

### **Dreams of France**

Andrea’s big dream as a child was to travel, but her concern was to be able to communicate. When she expressed this concern to her family, her father suggested that she learn the universal language of science and become a scientist. Thus began her career path.

Andrea is originally from Slovakia and was born in the small town of Trnava 37 years ago. Not surprisingly, she has made France her personal and professional home since she fell in love with France, its language and culture as a young girl.

Andrea Bachrata is currently head of a research laboratory at CEA in France where she is in charge of team performing experiments related to severe accident research and nuclear safety.

### **The path to the dream becomes reality**

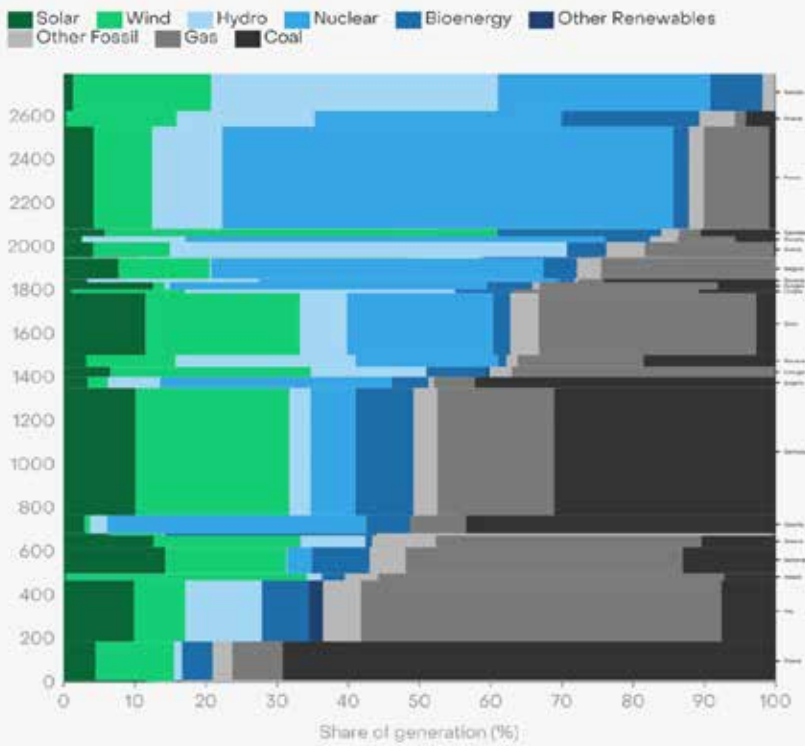
Andrea took up the challenge by undertaking an engineering course in Nuclear Studies in Prague. Not an easy choice by any means, especially for girls who were significantly underrepresented in engineering studies of any kind at university then. Nonetheless, she pursued her goal and during her study she travelled in the EU. Her dream of France became a concrete reality when she gained an Erasmus study opportunity with a six-month internship at CEA in Grenoble. After graduating she made the clever decision to do a PhD in the EU, at Institut de Radioprotection et de Sûreté Nucléaire (Institute for Radiological Protection and Nuclear Safety) in Cadarache, focusing on nuclear safety, model development and the interpretation of experiments. This proved to be the perfect preparatory route to her current role, which presents her with not only challenges but also opportunities.

### **What are the challenges and opportunities in your work?**

“The most challenging work is managing the team and keeping know-how and research at the highest level. The complexity that is inherent in my role means that I am faced with the challenge of defining the strategy in link with the objectives, and maintaining a

## Electricity generation across the EU

Electricity generation (TWh, y-axis) and share of electricity (% , x-axis)



**Figure 1** Source: <https://ember-climate.org/insights/research/european-electricity-review-2023/#chapter-3-eu-electricity-trends-eu-electricity-generation>

*“Women preparing a green, inclusive, sustainable future for all”*

- Woman in Nuclear (WIN)

high level of motivation among a team of 22 people of different ages and backgrounds, from young engineering graduate and PhD students to more experienced acclaimed Fellows. This motivation includes knowledge transfer and the personal development of each team member. But in these challenges, I find reward and opportunity, especially when I succeed in keeping the motivation of my team high and being part of that team as well as contributing to work of a high quality. I am especially grateful that in my career, I was encouraged by “role models” I met as a member of Women in Nuclear (<https://win-global.org/>). Thanks to this network, I “dared” and applied for a position of laboratory manager. Performing this huge step, I feel valued and welcomed by CEA.”

### What do you think about the Key Digital Technologies for nuclear power plants of the future?

“In this context, it is not important whether one is for or against nuclear energy in the future, but rather to continue research to ensure safety and an optimisation of the nuclear fuel cycle, without precluding the use of this alternative energy. Key Digital Technologies are fundamental to this goal and will lead to advanced construction methods and the design of the nuclear power plants of the future. They will be central to the development of electronic components and systems for the rugged and harsh conditions that applications encounter in the nuclear power plant environment. Not only will these key digital technologies help to optimise the entire Nuclear Fuel Cycle (*figure 2*), but in particular they will facilitate the research that will lead to innovation and thus eco-sustainability, enhancing safety for future new generations of reactors.”

### What energy-enabling technologies are needed?

“In the current European landscape there are a number of areas where improvements to the existing product can, and must, be made. One of these is advanced manufacturing. Another is digitalisation. Both are becoming increasingly prominent in the European industry landscape and will offer more efficient high-performance processes. In the Nuclear Power Plant sector, there is a willingness to consider advanced materials but in order for them to become a part of the ‘music’ (energy production) some improvements still need to be made.” Some European groups have pointed out that micro nuclear power, a cutting-edge technology enabled by embedded electronic



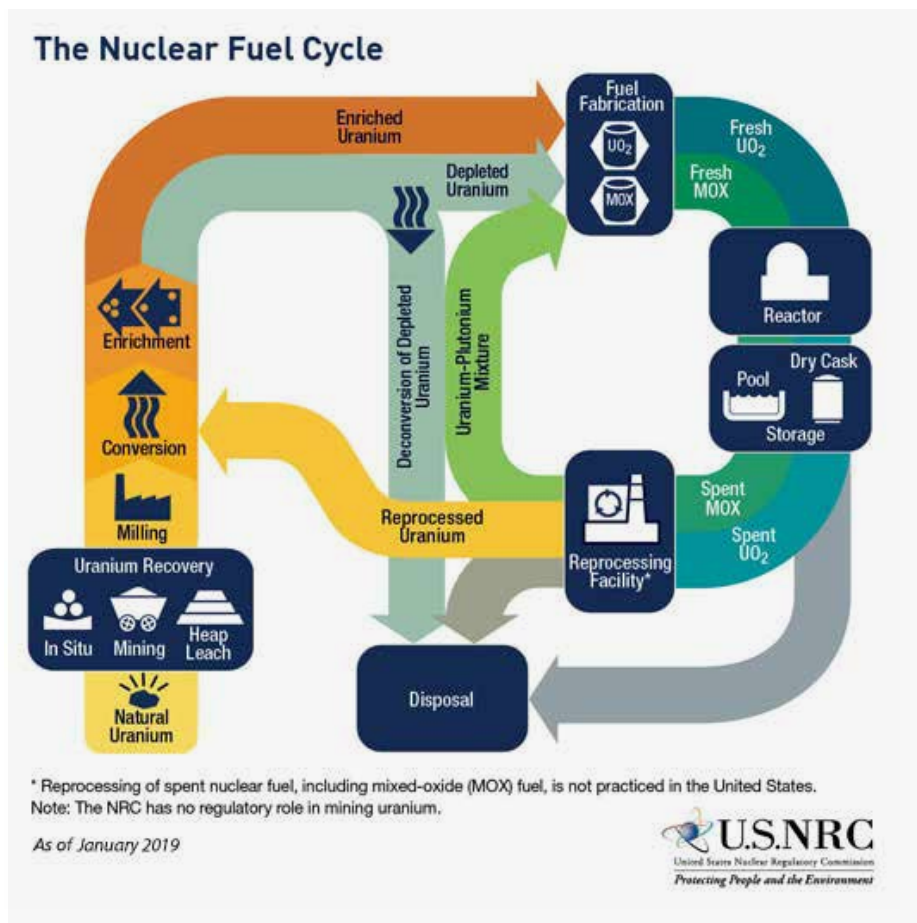


Figure 2 Image source: <https://www.nrc.gov/materials/fuel-cycle-fac/stages-fuel-cycle.html>



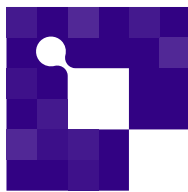
Andrea Bachrata Kubic  
 Head of Laboratory at CEA

components and systems, could be the solution to simplify the value chain, increase cybersecurity (as it applies a decentralised model), and have more visibility on local energy consumption. This is a familiar theme running through Andrea’s work. “We have two objectives: firstly, to provide electricity in difficult areas where they need it, such as Africa and Latin America, so we are putting a lot of effort into educating people and creating local nuclear engineers to prepare the future; and secondly, to produce heat for industrial production, especially in developed countries, (clean energy) and accelerate the CO<sub>2</sub> objective, reducing it to zero.”

**Making a difference, how?**

“One of the biggest problems of our days is the energy supply and the energy transition; the importance of advanced manufacturing and digitalisation cannot be overstated. Given the needs and objectives of the nuclear power plant sector, and in particular the critical importance of safety and security, it is becoming more and more clear that embedded cyber physical systems will be crucial to helping this sector achieve its objectives of supplying safe, sustainable,

and secure energy for the future.” Andrea is significantly advancing the realisation of these objectives as a prominent female figure in the nuclear power research and industry.



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**Submissions**

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](mailto:info@inside-association.eu)

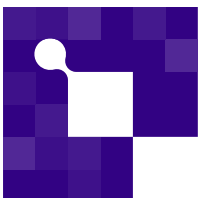
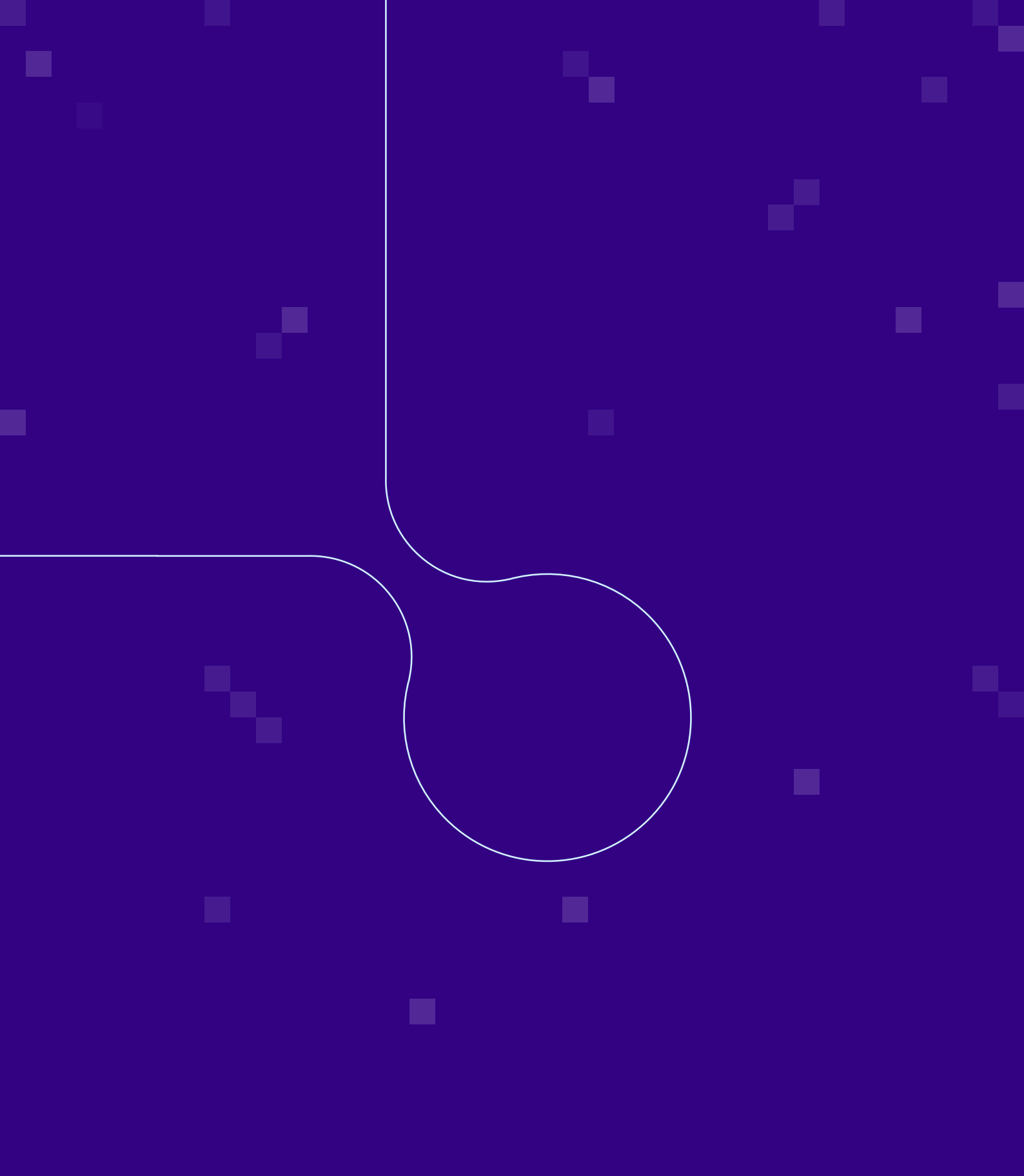
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