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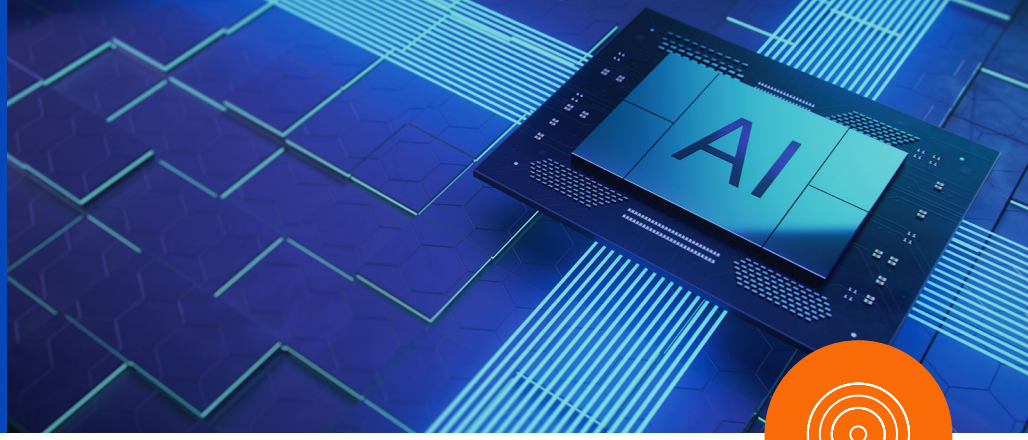


Project Results

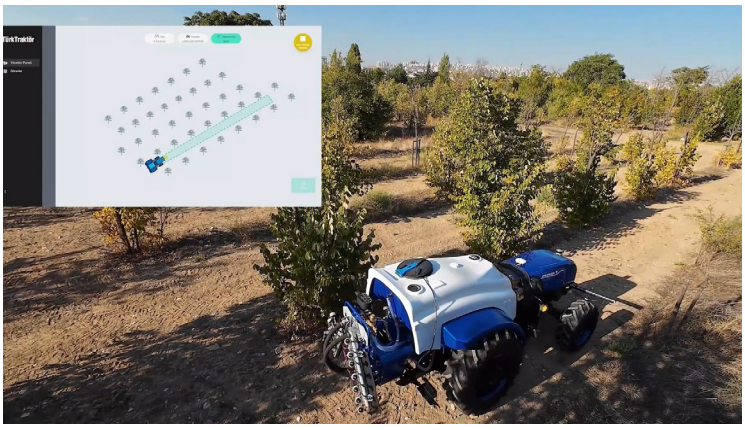
EFICAS

Optimising energy efficiency for AI-driven autonomy

To strike a balance between performance and energy efficiency when deploying artificial intelligence (AI) on autonomous and/or mobile devices, the ITEA project EFICAS (Energy Efficient Heterogeneous AI Framework for Smart Mobile and Embedded Systems) created a software framework and algorithm library to optimise energy consumption across heterogeneous computation environments.

Practically all mobile applications are severely power-limited. This is an obstacle to large business cases as increasing the functional complexity of mobile and autonomous applications increases the computational load and power demands of embedded platforms. This is especially true when introducing the complexity of AI. To be truly autonomous, mobile platforms also need to run for long periods without requiring an external power source. These factors all necessitate lower energy consumption.

To achieve this, EFICAS developed a software platform to balance energy use and computational accuracy and to implement intelligent resource management across heterogeneous hardware. This includes a middleware for runtime task scheduling on diverse compute platforms and an energy-efficient AI library for unified perception and decision-making. As a result, EFICAS was able to demonstrate energy optimisation across three use-case domains. In agriculture, the project developed an autonomous vehicle with localisation, navigation, object identification and equipment usage, as well as a high level of perception and decision-making during field applications. In the second use-case, autonomous mobile robots with full autonomous capacity were used as test vehicles to implement AI-driven algorithms that optimise energy consumption. Finally, EFICAS investigated perception for industrial automation tasks in heterogeneous edge computing environments.



EFICAS autonomous sprayer

Technology applied

The project's main output is the EFICAS framework, a no-code platform that has achieved end-to-end deployment in the cloud. To align with modern software trends, EFICAS uses a microservice-based architecture that prioritises containerisation, virtualisation, ease of implementation, and a lightweight, flexible design. This framework has enabled the development and deployment of energy-efficient AI algorithms in the form of a library for monolithic and federated perception and decision-making in complex situations.

With the AI library, users can access models that have been trained and implemented on different data types and that offer a wide variety of classification, regression, clustering, computer vision, anomaly detection and time series functions. These can then be deployed to edge devices to optimise the energy consumption of applications.
Across the use-cases, EFICAS demonstrated various ways in which this energy optimisation can benefit different domains. For logistics, the EFICAS framework offers reduced peak power draw and therefore an extended uptime.

For industrial automation, improved energy efficiency enables a higher throughput under mixed loads. In the agricultural use-case, EFICAS not only demonstrated how lower overall energy usage increases the operational range of autonomous vehicles but also developed a prototype agricultural sprayer vehicle capable of autonomous navigation, obstacle avoidance and variable rate spraying. This marks the first application of such a vehicle in the agricultural domain.

Making the difference

A major strength of the EFICAS platform is its emphasis on heterogeneous hardware, having tested the same models on both graphics processing units (GPUs) and field-programmable gate arrays (FPGAs). In doing so, the project achieved energy savings of 5-10% and demonstrated that FPGAs offer greater energy optimisation, making

them a more natural choice for mobile and autonomous applications. In total, the project developed 45 algorithms to work with edge devices and the cloud (versus a starting point of zero) and made 43 of these available in the AI library to be downloaded and applied when necessary. This approach provides flexibility as users can choose to optimise energy efficiency or sacrifice it for higher power based on their application's status in any given moment.

From a commercial perspective, the global AI market is projected to grow from USD 372 billion in 2025 to USD 2,407 billion by 2032 at a compound annual growth rate of 30.6%. EFICAS provides a foundation through which the consortium can enter or expand in this domain, including through new products or services that offer reduced downtime and energy costs. Benefits have already been felt by the partners: nine recruitments have been made – a significant number for a project of mostly SMEs – and EFICAS has received publicity in the form of five publications and an agricultural fair launch of the sprayer vehicle. By making the framework and library available as open source and pursuing standardisation, the results can also be expanded to new applications, such as portable medical devices or supply chain sensors.

The future

To take these next steps, various EFICAS partners will participate in follow-up projects, including on AI-driven electric vehicle charging infrastructure and next-generation AI hardware in industrial automation. Use-case trials will also be conducted to help bring the agricultural sprayer vehicle to the market. In the longer run, the uptake and further development of the project's results is about more than reducing the total cost of ownership of AI deployments. With increasingly strict regulations on energy consumption and a largescale shift towards autonomous, connected machinery, the societal demand for real-time optimisation – and for EFICAS' innovations – is only set to grow.

Major project outcomes

Dissemination

- Peer-reviewed literature consisting of seven papers accepted, published or under final review (e.g., ML4CPS 2023, DTPI 2023, TOK 2024)
- More than ten oral or poster presentations delivered at international and regional venues including ICECET 2025, ASYU 2025 and the Bursa Agricultural Fair 2024.

Exploitation (so far)

New products:

- EFICAS software framework: A "no-code" edge - AI platform that balances energy consumption and computational latency.
- EFICAS AI Library: A catalogue of 45 optimised models ready for multi-domain deployment on GPU and FPGA edge devices.
- Autonomous Orchard Sprayer: A fully electric, unmanned agricultural machine equipped with EFICAS-enabled perception and variable-rate spraying.
- Edge Data Acquisition Device: Jetson Nano CAN-bus gateway securely streams EV telemetry via MQTT/FIWARE.

New services:

- Digital-Twin Predictive Maintenance: Digital-twin analytics predicting failures using the models in EFICAS AI library.
- Energy-Smart AMR Optimizer: Retrofit scheduler cuts AMR battery use, lengthening mission duration.
- Full-Stack Energy Benchmark Suite: Measures software & hardware energy consumption.

New systems:

- Zero-Code AI Architect: Generates custom CNNs from backbones, deploys directly on edge.
- Multi-Model Parallel Runner: Executes models concurrently; benchmarks speed, energy, resource footprints.
- Conveyor-Twin Academic Testbed: Digital-twin belt system for predictive-maintenance research and validation.

ITEA is the Eureka RD&I Cluster on software innovation, enabling a large international community of large industry, SMEs, start-ups, academia and customer organisations, to collaborate in funded projects that turn innovative ideas into new businesses, jobs, economic growth and benefits for society. ITEA is part of the Eureka Clusters Programme (ECP).

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Partners

Denmark

- Danfoss Drives
- University of Southern Denmark

Türkiye

- Acd Bilgi Islem ltd.sti.
- Inovasyon Muhendislik
- Patika Robotik Arge ve Mühendislik San.Tic.A.Ş.
- Turk Traktor ve Ziraat Makineleri A.S.
- YONGA TEKNOLOJİ MİKROELEKTRONİK ARAŞTIRMA GELİŞTİRME TİC. LTD. ŞTİ.

Project start - end

September 2021 - June 2025

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https://itea4.org/project/eficas.html

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