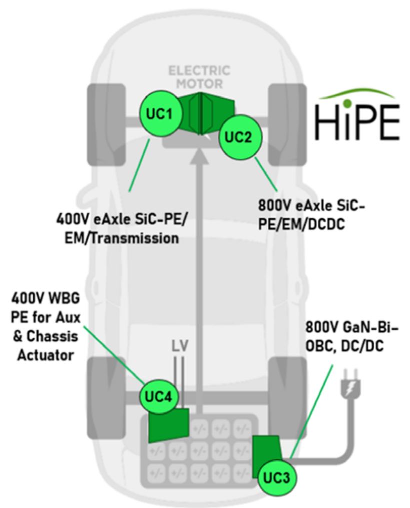
HiPE

High Performance Power Electronics Integrations

Second HiPE Newsletter November 2024

NEWSLETTER CONTENT



Funded by the European Union

The HiPE consortium is happy to provide the **second project newsletter**.

The HiPE project, focused on developing cutting-edge power electronics (PE) for battery electric vehicles (BEVs), has completed two years of work, making significant progress towards its key objectives. The project **aims to improve energy efficiency, reduce costs, minimize size and weight, enhance reliability, and meet automotive quality standards for power electronics**. By leveraging wide bandgap (WBG) semiconductor technologies, HiPE is driving innovation in power electronics for the next generation of electric vehicles.

HiPE is working to **improve the efficiency of WBG power electronics systems** by optimizing the proximity of gate drivers to power devices. This helps generate cleaner switching signals, enhancing overall system performance and reducing electromagnetic interference (EMI). Cost reduction is another central goal of HiPE. A detailed methodology for calculating retail prices, Total Cost of Ownership (TCO), and cost-effectiveness has been outlined aiding in the understanding of the economic impact of WBG-based systems.

To address **size and weight reduction**, HiPE has conducted extensive research into semiconductor cooling and thermal management, critical components for system downsizing.

HiPE **aims to enhance reliability through integrated design and intelligent control systems**. The project has developed simulation models, including digital twins, to assess the impact of proposed solutions across a wide range of vehicles. These models also support functional safety, predictive health monitoring, and reliability improvements for the four HiPE use cases.

HiPE continues to advance the integration of WBG technologies into electric vehicle systems, including work on 400V SiC inverters, advanced chassis actuators, and 800V WBG on-board chargers and DC/DC converters. The project is on track to deliver further innovations in energy efficiency, cost reduction, and reliability improvements for BEVs. Through collaboration and cutting-edge research, **HiPE is set to make a significant impact on the future of electromobility**.

This year's newsletter highlights the **key progress** in the HiPE project, including updates from the Work Packages, recent publications, and the dissemination activities involving project partners. It provides a concise overview of how HiPE is advancing electric vehicle technology and engaging with the wider community.

1 Benefits for the Public

Boosting Europe's Electric Future: HiPE's Impact on EVs and the Environment

The EU-funded HiPE project is working to make electric vehicles (EVs) more affordable, efficient and reliable. By developing new power electronics using advanced materials, HiPE is helping to create smaller, lighter, and more energy-efficient components for the next generation of battery electric vehicles (BEVs). These innovations will make electric vehicles more attractive to the public and accelerate their uptake.

Cleaner air: Electric vehicles do not produce harmful emissions such as nitrogen oxides (NOx) and particulate matter, which contribute to air pollution. HiPE will help reduce these pollutants by making EV technology more accessible, leading to healthier cities and cleaner air for everyone.

Lower costs: HiPE's new technologies aim to reduce the price of EVs by around 10%. This means more people can afford to switch from traditional gas-powered cars to electric alternatives.

Energy independence: Currently, Europe depends on imported oil for almost all of its transport energy. By advancing EV technology, HiPE is helping Europe reduce its dependence on fossil fuels and enhance its economic security.

European innovation: HiPE supports the European industry by developing domestic solutions. This helps reduce the need for imported technologies and strengthens Europe's leadership in the global EV market.

By making electric vehicles more efficient, affordable and environmentally friendly, HiPE is driving Europe towards a cleaner, healthier and more energy independent future.

2 What is going on in the HiPE Work Packages?

As the HiPE project progresses, each Work Package is making significant strides toward advancing next-generation technologies for electric vehicles. The teams are working collaboratively to achieve the project's ambitious goals. In this update, we take a closer look at the key activities and developments within the Work Packages.

2.1 Work Package 1 – Project Management

During the first two years of HiPE, significant progress has been made towards achieving HiPEs ambitious project goals. A key **focus** has been establishing **strong project management processes** to ensure that the project partners stay on track and deliver high quality results.

To support this, the consortium has **established an administrative structure and management system** for the project that is fully aligned with EU requirements. This includes the establishment of **two key steering boards**: the Technical Steering Board and the Strategic Steering Board, which provide scientific and strategic guidance throughout the project.

These efforts have laid the **foundation for the next phases of HiPE,** setting us up for success in developing innovative, energy-efficient solutions for the future of electric vehicles.

2.2 Work Package 2 – Requirements and Specifications

The primary **goal of Work Package 2** was to **define the requirements and specifications** needed to coordinate the work of all contributors in the HiPE project. This ensures the smooth creation of a physical demonstrator where HiPE's innovations will be implemented. škoda led the coordination of this Work Package, including tasks 2.1 and 2.2. The Technical University of Ilmenau was responsible for task 2.3, while Ford Otosan led task 2.4.

Task 2.1 Automotive requirements and specifications

In this task, the technical contributions of each HiPE partner were outlined, d**etailing vehicle requirements and industry standards for each use case**. The document highlights customer expectations and references 14 ISO norms, 10 UL standards, 4 IEC standards, and 2 European regulations. This comprehensive overview **provides** a clear understanding of the **expected outcomes and benefits for customers** across all four use cases.

Task 2.2 Systems interfaces, protocols, and integration

Task 2.2 focused on **outlining the mechanical dimensions, electrical, and electronic parameters** for all HiPE use cases. It also detailed the data communication protocols needed to ensure seamless integration between components and systems, facilitating their assembly into powertrains and vehicles.

Task 2.3 Integration plan and testing specifications

Task 2.3 outlines the **testing requirements, specifications, and necessary hardware and software** for evaluating components and technologies developed by project partners. It covers both **virtual and real test environments**, including the protocols and interfaces needed to connect them. Additionally, this task focuses on the integration planning of individual components at various test levels, ensuring a cohesive testing process across the project.

Task 2.4 Simulation requirements

Task 2.4 established the **simulation requirements for each HiPE Use Case**, ensuring alignment on tools, inputs, outputs, and structures across the different project partners.

The **main objectives** of the task were:
- Simulation requirements and interconnections for all the virtual Use Cases
- Simulation software
- Required modelling depth
- Simulation-related KPIs

After contacting each partner and gathering feedback on the simulations they were going to perform, the common requirements were detailed in the corresponding deliverable.

2.3 Work Package 3 – Digital Twins for Modular and Scalable Power Electronics Architecture, Functional Safety, Reliability, and Predictive Health Monitoring

Work Package 3 focuses on **simulation activities** within the HiPE project to **evaluate vehicle performance improvements brought by WBG-based Power Electronic (PE) solutions for the traction inverter, On-Board Charger (OBC), DC/DC converter, and auxiliary drives**. The simulations aim to quantify efficiency gains, dynamic response enhancements, and overall drivability improvements at the vehicle level. The proposed modular and scalable PE architecture also supports applications across a wide range of vehicle segments, ensuring adaptability and broad impact.

Currently, **surrogate models of PE components** in Use Cases 1-4 and their affiliated subsystems (e.g., e-axle powertrain) **are developed with sufficient accuracy based on dedicated design and simulations, and implemented in MATLAB/Simulink**. This approach allows for time- and cost-effective simulations before prototyping. Representative production vehicles have been selected, and their dynamics are modelled using AVL VSM with high fidelity. To assess the reliability of PE components, CDTs (Cyber-Physical Twins) are developed to accurately capture their thermos-mechanical properties by employing AI techniques. These CDTs are integrated into the vehicle simulator, enabling the prediction and evaluation of component reliability under various driving scenarios.

In the **next project phase**, intensive simulations are planned, with the component models continuously updated in line with the progress of other Work Packages. High-level controllers will be developed to leverage the enhanced features of the components, optimising both vehicle performance and component reliability.

2.4 Work Package 4 – Integrated WBG-based Power Electronics: Key Achievements and Innovations

ŠKODA AUTO's innovative venture under Task 4.1 marks a leap in e-mobility, **developing a 400V SiC-Inverter/EM system seamlessly integrated into a 2-speed gearbox** for the škoda Enyaq. This synergy between cutting-edge technology and engineering acumen paves the way for EVs that are not only efficient but surpass current standards of CO2 emissions. A two-speed gearbox conceptualized from this initiative showcases the potential for excellence when modularity meets functionality.

Furthering the project's scope, Task 4.2, led by the Technical University Ilmenau in conjunction with Tenneco, shines a spotlight on the **incorporation of sophisticated chassis actuators armed with 400V GaN power electronics**. Tenneco's creation of next-gen lifting devices epitomizes the project's commitment to elevating vehicle performance and comfort to unprecedented heights.

Ford Otosan head of Task 4.3, introducing the world to the COMBO PCM, an ingenious unification of an **On-board Charger (OBC) and DC-DC converter**. This dual-functionality engineering marvel exemplifies how space optimization and complexity reduction can significantly boost charging efficiency, marking a new era in Battery Electric Vehicles (BEVs) development.

Marelli takes the helm in Task 4.4, dissecting electric system layouts to uncover the **most efficient design for high-performance inverter systems**. Through meticulous analysis and testing, the project brings to light the unmatched potential of SiC inverters in reducing switching losses and overall device size, laying the groundwork for lighter, more efficient EVs.

Task 4.5, under the guidance of Ideas & Motion, ventures into the **integration of power transistors and gate drivers**. This exploration fosters a thorough understanding of their interplay, advancing towards best practices in power electronics systems' performance and efficiency. Early successes, including the successful testing of a SiC-based Power Module and the assembly of the first SiC-based inverter, herald a promising horizon for real-world applications.

2.5 Work Package 5 – Testing, Evaluation & Demonstration

Work Package 5 essentially deals with two main topics: the value analysis and cost assessment of HiPE technologies, and the testing, evaluation, and demonstration of these technologies.

The **value analysis and cost assessment of HiPE technologies** covers a long-term horizon (M7-M36) and involves the comparison of HiPE technologies against baseline battery electric vehicles (BEVs). These baseline vehicles include a passenger car with a 400V system and a light commercial vehicle with an 800V system, both serving as benchmarks for value analysis and cost assessment in the project's use cases. Specific evaluation concepts and parameters have been developed to guide this process. Additionally, HiPE-specific methodologies have been established, along with brand-independent factors for assessing the Total Cost of Ownership (TCO) at both component and vehicle levels. These methodologies also support Cost-Benefit/Cost-Effectiveness Analyses (CBA/CEA).

The second focus of this Work Package is on **testing HiPE technologies**. Baseline and benchmarking procedures were defined early in the project, laying the foundation for later evaluations. Standardized and recognized testing procedures will be used to showcase the advancements of HiPE components compared to current market technologies. These procedures will also guide the preparation of test setups and demonstrators for evaluating the components and systems developed within HiPE.

In the **project's third year**, the defined **test procedures will be implemented to evaluate HiPE technologies** at both the system and vehicle levels. At the system level, individual components and networks of components will be tested in a lab environment, with data thoroughly analysed. At the vehicle level, testing will involve both complete vehicle demonstrators and systems representing full vehicle functionality. These tests will take place in both laboratory settings and real-world environments at dedicated proving grounds. Simulations will also be employed to complement the testing at both levels.

2.6 Work Package 6 – Thermal Management and Co-Simulation of System

Work Package 6 mainly focuses on d**eveloping and analysing efficient cooling solutions for E-powertrain components**. In the previous year, different methods of cooling were analysed to have an efficient thermal management of the power inverter used in powertrain. **Cooling channel with innovative surface enhancing structures (pin-fins)** were studied to develop the most effective structure which will contribute the best for effective cooling.

Work done: 1) Module level experiments

Now to move forward, the **surface enhancing structures (pin-fins) were manufactured and tested at small module level**. The main purpose of the pin-fins is to increase the surface area. More area means more possibility to **transport the heat away** from heated power electronics parts, which in turn mean **better cooling capacity**. These module level experiments helped us to judge the performance of the cooling channels and pin-fins (technically called 'Heat-sinks'). The experimental results were compared with the simulation results for validation. Figure 1 shows the manufactured pin-fin structure and the experimental setup.

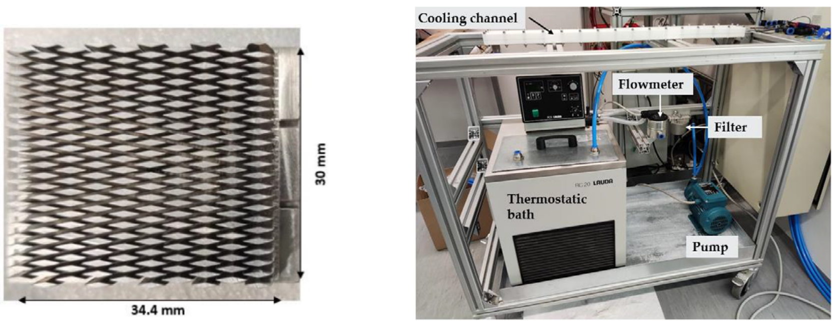


Figure 1: Prototype of the pin-fins and Experimental setup

The experimental and simulation results are compared based on the thermal resistance. The thermal resistance Rth describes thermal resistivity, which indicates the ability of given material to resist heat flow. This means the low Rth is desirable. The compared thermal resistance is shown in Figure 2.

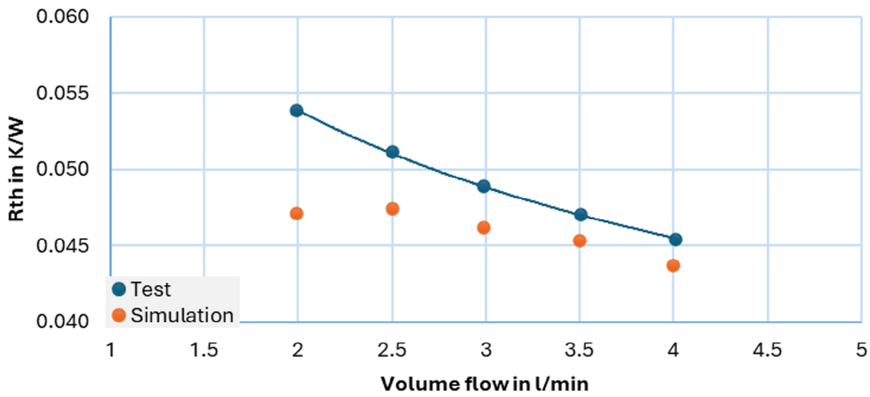


Figure 2: Thermal resistance comparison

Reduced Order models for Computational Fluid Dynamics simulations (CFD)

Advanced cooling methods for power modules were explored in previous tasks. To analyse various design parameters and scenarios, CFD simulations often require more computational time and are expensive. As a result, there is a necessity of efficient computing the temperature to reduce computational effort. Thus, a **reduced order model is developed (ROM**) to predict the desired results in seconds. The workflow (Figure 3) involves:

Collecting training data from simulation results.

STEP 01

Training the ROM using machine learning with suitable reduction and approximation techniques.

STEP 02

Perform error analysis to identify the best possible technique and improve prediction quality.

STEP 03

Using the trained model to predict new results with different inputs in seconds.

STEP 04

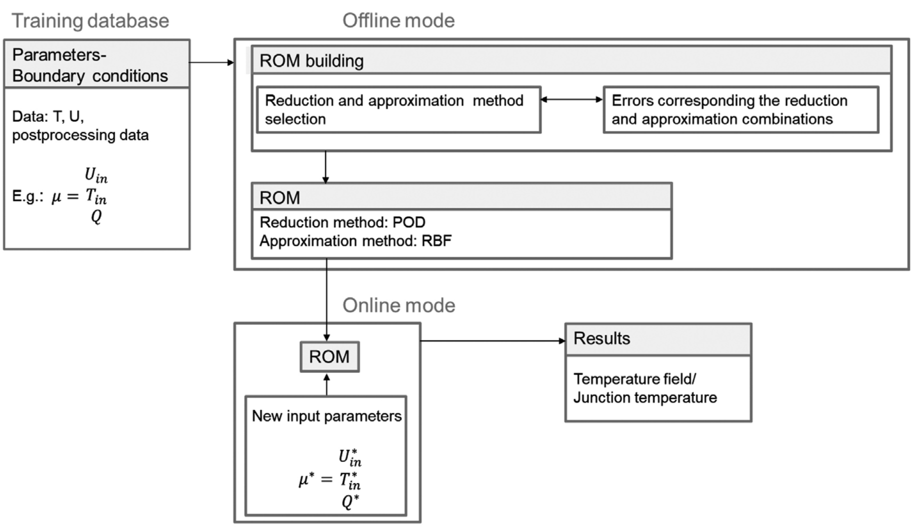


Figure 3: ROM Workflow

Planned activities for this year:

A 1D thermal management environment of a vehicle e-Axle is to be developed in Matlab-Simulink. Main aim will be to find out the layout which will increase the efficiency of the e-Axle and in turn reduce the energy consumption. Predictive control methods will be used to optimize system and further develop the efficient powertrain thermal management system.

The **thermal reduced order model**, which is developed **will be integrated into the entire vehicle framework** to create a digital twin for predictive health control and management. Further research will be done to improve the ROM for fluid dynamics aiming to reduce errors.

2.7 Work Package 7 – Dissemination, Communication and Exploitation

Work Package 7 focuses on the **dissemination, communication, and exploitation** of the HiPE project's outcomes. This includes the **creation of dissemination materials** such as the project website, social media channels, flyers, and roll-up banners. Additionally, it involves **representing the project at various events** and maintaining contact with key stakeholders (e.g., similar projects, the research community, industry, authorities, and the public). An overview of all project publications is also maintained. More details about the dissemination and communication activities so far can be found in the section "Dissemination Activities So Far".

The **exploitation** aspect focuses on the future plans of the project partners and how they will apply the knowledge gained throughout the project. As part of this, **Key Exploitable Results** (KERs) have been identified, and an initial **Exploitation Survey** was conducted. The survey consisted of four sections: contact details and GDPR-related questions, general questions (including interest, expectations, roles, business cases, etc.), questions regarding service/product deployment, and questions for academia and further research.

Work Package 7 also includes activities aimed at **standardizing** HiPE innovations and technologies for the international market. The first step involved **gathering relevant regulations and standards** applicable to HiPE. In the coming months, the project consortium will discuss how to further standardize HiPE's innovations.

As the HiPE project progresses, a significant emphasis is placed on collaboration and knowledge dissemination. Upcoming general assemblies will focus on **preparing joint publications** among project partners, highlighting the technological advancements made within the project. This collaborative effort aims not only to share knowledge within the consortium but also to contribute to the broader scientific and industrial community.

3 Abstract of HiPE publications

Up until now **two conference papers** were published in the course of HiPE and are presented in this Newsletter.

3.1 I&M, Tenneco: "Design of a Smart Actuation for a Fully Electrified Suspension System"

The paper proposes an **advanced electro-mechanical levelling system** tailored for electric vehicles (EVs). The system operates at high voltage using wide band-gap semiconductors, eliminating the need for DC-DC converters, which simplifies the architecture and enhances vehicle efficiency. The smart actuator adjusts the vehicle's ride height in response to various driving conditions, optimizing aerodynamics and increasing the vehicle's range.

The system is designed to **improve energy efficiency by dynamically adjusting the vehicle's height** based on conditions such as trunk loading or road surface variations. For example, at highway speeds, lowering the vehicle reduces air resistance, thus extending the EV's driving range. The **system is designed with modularity in mind**, allowing it to be adaptable to various auxiliary systems. The control unit communicates with other vehicle systems to ensure seamless integration with the vehicle's environment and user commands.

Extensive **simulations were conducted** to evaluate the actuator's performance in terms of power consumption, thermal management, and mechanical response. The simulations showed promising results in optimizing both the motor's electrical and mechanical subsystems, achieving up to an **85% reduction in power losses by using GaN transistors**. These preliminary results suggest that the system offers a more efficient, less complex solution for electric vehicle suspension, with a clear path toward real-world application.

Link to publication: [Design of a Smart Actuation for a Fully Electrified Suspension System (researchgate.net)]

3.2 I&M: "Measurement of PCB-Related Commutation-Loop Inductance Using a Vector Network Analyzer"

This publication **explores a method to measure and characterize the stray inductance in Printed Circuit Boards (PCBs) using a Vector Network Analyzer (VNA)**. Stray inductance in a PCB's commutation loop can lead to significant inefficiencies in power converters, resulting in oscillations, increased electromagnetic interference (EMI), and switching losses.

The paper **proposes a reliable method for using VNA to evaluate the impedance of a bare PCB trace**, offering an accurate way to compare different PCB designs. By focusing on the frequency range between 100 kHz and 100 MHz, the study identifies the impact of PCB layout on inductance and resistance, essential for understanding how these factors contribute to EMI noise and efficiency losses.

Two versions of a PCB design were tested, showing that a **design optimized with a full ground plane significantly reduces stray inductance and resistance**. This approach is particularly **useful in power electronics applications**, where high-speed switching using wide band-gap devices exacerbates issues related to stray inductance. The authors conclude that this method is highly sensitive to layout variations and can be instrumental in optimizing PCB designs to minimize EMI and improve overall efficiency in high-power systems.

This paper was presented at the **EMC Compo** in Turin from the 7th – 9th October 2024. Therefore, no publication link is available yet.

4 Dissemination Activities so far

The realised dissemination activities in the table below are showing all dissemination activities done from the project start until November 2024.

4.1 Dissemination Basics

The HiPE project has developed a range of communication tools to support outreach and engagement. These materials include:

- **Logo:** A distinctive brand identity for the project.
- **Flyer:** Providing key information about HiPE's objectives, goals, and innovations.
- **Roll-up Banners:** Used for visibility at events and exhibitions.
- **Templates:** Standardized documents for the project consortium to maintain consistency in communication.

HiPE

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Figure 4: HiPE Logo

4.2 Online Presence

The HiPE project's online presence is centered around its **website and LinkedIn profile**.

The **website** offers a comprehensive overview of the project, including its objectives, use cases, Work Packages, and the partners involved. Visitors can also explore the latest project results, publications, and updates. Designed for a wide audience, the site provides valuable resources for researchers, industry experts, and policymakers interested in cutting-edge electric vehicle technology.

The HiPE project maintains an **active presence on LinkedIn**, where the consortium regularly shares the latest updates, insights, and achievements from the project. Follow HiPE's page to stay informed about our progress, upcoming events, key milestones, and the latest news from the world of electric vehicle innovation. Whether you're a researcher, industry professional, or simply curious about cutting-edge technology, HiPE's LinkedIn page offers valuable content and networking opportunities. Currently, the HiPE LinkedIn page has 105 followers in total.

Be sure to check out the **news section** on the website for regular updates and follow on LinkedIn to stay connected with the HiPE community.

The website and LinkedIn profile can be accessed through **"General Project Information"**.

4.3 Conferences & Exhibitions & Webinars

HiPE and E-VOLVE Cluster (of which HiPE is part of) representatives visited several Events to represent the project.

Science Fair 2023

Location and Date: Prague, June 8-10 2023

Represented by: UTIA

In the course of the Science Fair 2023, UTIA represented HiPE by doing a dedicated project presentation.

Figure 5: UTIA representation of HiPE at Science Fair 2023

FISITA 2023

Location and Date: Barcelona, September 12-15 2023

Represented by: ViF and E-VOLVE Cluster representatives

In cooperation with the E-VOLVE Cluster, HiPE took part in this leading automotive event by presenting the project and its aim to the FISITA visitors.

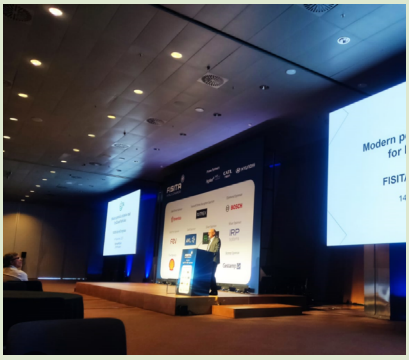

Figure 6: FISITA 2023

EARPA Forum 2023

Location and Date: Brussels, October 17-18 2023

Represented by: ViF and E-VOLVE Cluster representatives

Project partner ViF hosted a booth at the exhibition, again collaborating with the E-VOLVE Cluster.

Figure 7: EARPA Forum Booth

A3PS Conference 2023

Location and Date: Vienna, November 16-17 2023

Represented by: ViF, IESTA, and E-VOLVE Cluster representatives

HiPE was highlighted during the E-VOLVE Cluster presentation at the event.

Figure 8: A3PS Conference 2023 E-VOLVE Cluster Presentation and Discussion Panel

RTR Conference 2024

Location and Date: Brussels, February 05-07 2024

Represented by: ViF

At this conference, the project partner ViF delivered a comprehensive project presentation, focused on giving the audience an overview about the project and key advancements.

Figure 9: RTR Conference 2024

EARPA Spring Meeting 2024

Location and Date: Brussels, March 06 2024

Represented by: ViF

E-VOLVE Cluster Presentation (including HiPE) by ViF was held at the event.

Figure 10: EARPA Spring Meeting Presentation

E-VOLVE Cluster online Webinar

Location and Date: Online, March 15 2024

Represented by: UoS and E-VOLVE Cluster representatives

During this online Webinar, which was hosted by the E-VOLVE Cluster, several Cluster members were represented (e.g., EM-TECH, HighScape). HiPE partner University of Surrey (UoS) prepared and presented a presentation with the title "Toolchain for Vehicle-Level Simulation".

TRA 2024

Location and Date: Dublin, April 15-18 2024

Represented by: ViF and E-VOLVE Cluster representatives

The E-VOLVE Cluster had the opportunity to present and represent the Cluster at the CINEA Booth at this event.

Figure 11: E-VOLVE Cluster representing HiPE at the TRA 2024

Workshop on „D&C&E and Clustering Activities"

Location and Date: Online, May 14 2024

Represented by: ViF, E-VOLVE Cluster representatives and Battery Heroes

During this online workshop, ViF (together with Armengaud Innovate) – representing also the E-VOLVE Cluster and Battery Heroes Cluster – presented key examples of dissemination, communication, and exploitation (D&C&E) activities to EARPA. During this workshop, also lessons learned from both clusters have been provided and discussed with the participants.

Lange Nacht der Forschung 2024

Location and Date: Graz, May 24 2024

Represented by: ViF, E-VOLVE Cluster representatives and Battery Heroes

At this event, HiPE participated in a fun and educational activity for children, alongside several other projects, to explain the principles of battery technology and e-mobility. The highlight was the "Lemons as Power Source" station, where children learned how natural resources, such as lemons can, generate energy.

Figure 12: Lange Nacht der Forschung 2024

European Researchers Night 2024

Location and Date: Graz, September 27 2024

Represented by: ViF, E-VOLVE Cluster representatives and Battery Heroes

As with the "Lange Nacht der Forschung 2024", HiPE partners collaborated with the E-VOLVE Cluster and Battery Heroes during this event to engage children in a hands-on activity. The popular "Lemons as a Power Source" station offered a fun and educational demonstration of battery technology and e-mobility, showing how natural resources like lemons can generate energy.

Figure 13: European Researchers Night 2024

Upcoming E-VOLVE Cluster Webinar

The next E-VOLVE Cluster Webinar is just around the corner, so save the date for 22. November (10:00 - 12:00 CET). This edition will focus on "Smart Components for the Software-Defined Vehicle of the Future" and HiPE will again be represented with a presentation. Stay tuned for more information coming soon.

Figure 14: Upcoming E-VOLVE Cluster Webinar - Save the Date

General Project Information

More information on HiPE is available on our website: hipeproject.eu

Follow us on LinkedIn

Project Partners

Coordinated by

virtual vehicle

Partners

ÚTIA, AVL, MARELLI, nexperia, IESTA, i&m, University of Surrey, Ford Otosan, Tenneco, Fraunhofer ENAS, Škoda, Technische Universität Ilmenau

Project Facts

Project Coordinator: Bernhard Brandstätter
Company: Virtual Vehicle Research GmbH
Website: www.hipeproject.eu

Project Start: 1st November 2022
Project Duration: 36 Months
Consortium: 13 partners
Project Funding: 5,481,274 Euro

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