2nd Newsletter Edition/April 2021

## PROJECT MEETINGS

**General Assembly, online, June 9,2020**

Due to the COVID-pandemic, the General Assembly took place in the virtual space in June 2020. All Work Package leaders presented their work and discussed their challenges and next steps.

**General Assembly, online, February 11, 2020**

Still in the pandemic, the project members met online to discuss the current status of their work and the need for a project prolongation.

**Next General Assembly**

The next meeting will take place in 2 parts, the first one virtually early summer and the second one in autumn hopefully again face-to-face.

*The last gathering took place in Tel Aviv end of 2020*

## 2 YEAR SYS2WHEEL – DESPITE PANDEMIC GOOD PROGRESS

The project SYS2WHEEL aims at developing sustainable city logistics and improving mobility, accessibility and quality of life of EU citizens. **12 international project partners** are committed to achieve three main objectives:

1. Reducing cost in mass production by at least 20% through components becoming obsolete and through reduction of wiring costs.
2. Increasing powertrain efficiency by improved e-motor windings, advanced rare-earth magnets, reduced powertrain rotation parts, reduced losses, advanced control and weight reduction.
3. Increased affordability and user-friendliness by enhanced modularity and packaging. Space saving approaches in sys2wheel lead to more freedom for batteries, cargo and drivers.

The year 2020 was dedicated to developing components and controls that can be integrated into the demonstrator vehicles. The architectures of the two demonstrators are well described in two deliverables that can be downloaded via the project's homepage. Another public deliverable deals with control mechanisms for electrified propulsion and energy efficiency analysis of sophisticated torque vectoring controls.

Despite the pandemic SYS2WHEEL partners managed to stay on track and keep timing of the project until autumn 2020.

During the second wave of the pandemic, it became obvious that test field operators are only partially available, and the supply chain suffered. These circumstances led to a significant delay until beginning of 2021, which cannot be recovered anymore.

Other highlights were the common dissemination activities together with the **E-VOLVE cluster**. The cluster is realizing synergies between seven projects from the GV-01 Horizon 2020 call.

Connect with us and stay tuned!

## HIGHLIGHTS OF DISSEMINATION

**EVOLVE-Cluster presentations:** The 4th EVOLVE Cluster newsletter has been published on Dec 14, 2020: https://www.h2020-evolvecluster.eu/e-volve-4th-newsletter

**EUCAR Annual Reception** in Brussels, November 2020

**RT20 Conference:** The 4th edition of the RTR20 “Results from Road Transport Research in H2020 projects” organized by ERTRAC, EGVIA and the EC was held online on Nov 30 and Dec 1, 2021. A presentation of SYS2WHEEL was given by Alois Steiner.

**IEEE AEIT Automotive 2020 Annual Conference** in Turin, Nov 18-20, 2020

**A3PS Eco-Mobility 2020** in Vienna, Nov 11, 2020, presentation of first project results by project coordinator

**ERTRAC** in Brussels, Nov 30-Dez 1, 2020, presentation of project results

## UPCOMING EVENTS IN 2021

**A3PS Eco-Mobility 2021** in Vienna, Nov 2021

**EUCAR** annual reception late Autumn 2021, if held online, a presentation of the EVOLVE cluster project is planned

**EVOLVE-Cluster meetings:** SAE WORLD CONGRESS session on April 21-23, 2021: EVC1000 organizing session, 2 EVOLVE projects participating

**AEIT Automotive 2021** Annual Conference in Nov 2021: potential EVOLVE session suggestion (application open until April 30th), in cooperation with Fitgen and TELL

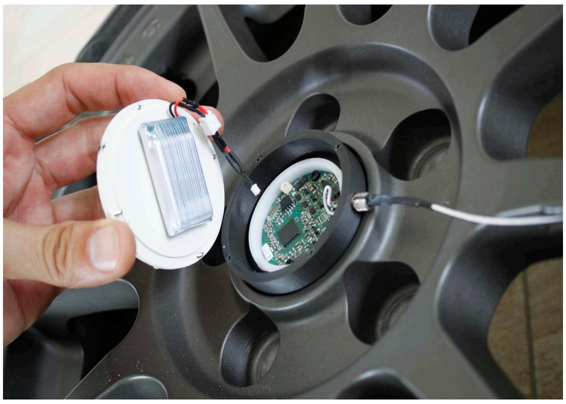
**EARPA Form Forum:** Nov 9, 2021**,** The Egg, Brussels

## IN-WHEEL ENERGY HARVESTER FOR SUPPLYING SENSORS IN THE WHEELS

HiWiTronics, a project partner in SYS2WHEEL, has developed a patented system which is able to harvest energy from rotating parts.

The **in-wheel energy harvesting device** offers the possibility to transmit signals, sensed in the wheel, with very high data rates to a controller at the chassis.

The signals will be transmitted at a frequency of 433 MHz due to the higher penetration depth. They will be used to control smoother acceleration of electrified vehicles to avoid unnecessary tire wear and air pollution from tire abrasion.



sys2WHEEL
co2 free city logistics

In 2020, the system including necessary sensors has been integrated into the rims of the in-wheel demonstrator vehicle of Tofas. Data communication and interfaces have been aligned with Tofas and TTTech Auto and have been accordingly implemented.

The exploitation strategy of HiWitronics involves further parameters to be measured with this device after the SYS2WHEEL project.

Therefore, parallel investigations are carried out whether friction coefficients can be measured by this system.

## IMPLEMENTATION OF IN-WHEEL E-DRIVE AND SUSPENSION SYSTEMS TO LIGHT DUTY COMMERCIAL VEHICLE

Implementation of in-wheel e-drive and in-wheel suspension systems to light duty commercial vehicles brings **substantial benefits**.

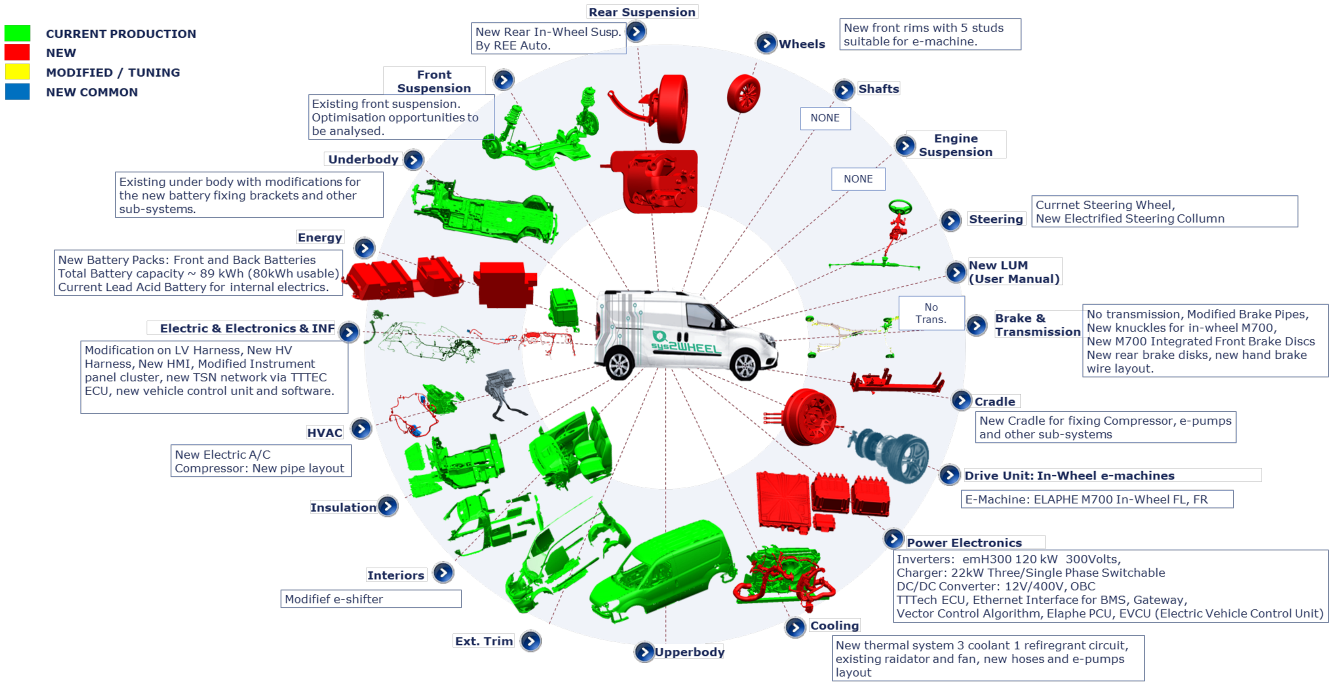
Reducing the number of powertrain components and parts of conventional suspension system provide **extra space for additional battery pack** or for the storage. Thanks to those modular systems, reducing the vehicle complexity and mass production cost becomes easier to reach.

Moreover, novel design for torque vectoring and advanced control algorithms, which collects data via sensors equipped to the wheels, are required to control in-wheel e-drive system.

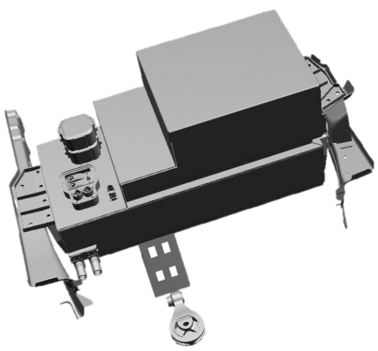
By considering rim size, an **ideal vehicle architecture** is defined in which two e-machines are mounted to front wheels while in-wheel suspension components are mounted to rear wheels.
The Elaphe PCU (Propulsion Control Unit) controller is considered as main controller for the propulsion system which consists of two M700 e-machines driven by two inverters. Harvester units are mounted to collect and transmit data from the front wheels. This information is used as an input for **advanced control algorithm** which is being developed by our project partner University of Surrey.

It is crucial to identify which parts carry over from donor vehicle (marked in green in the following figure) and which ones are new (marked in red) or need to be modified. **Visual Bill of Materials** (BOM) studies are performed after the alignment of the location of in-wheel e-drive and suspension systems.

Finally, the visual BOM as shown in the following figure is used as a reference for further design and implementation activities:



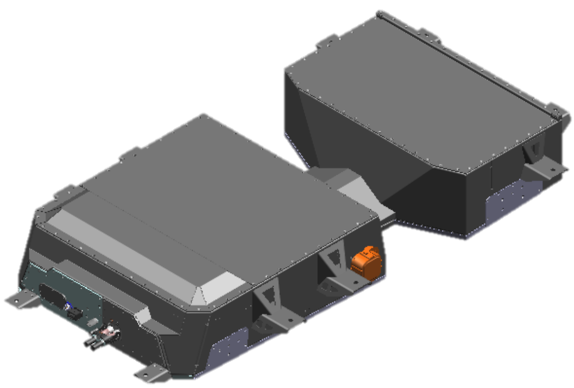

One of the important activities carried out in SYS2WHEEL is designing **two separate battery packs** with a co-design company. The total battery capacity reaches 89 kWh. The range of the vehicle is expected to be increased by ~20% by this additional battery pack thanks to in-wheel drive technology.



**Front Pack: 17,8 kWh (Gross)**

**Impact of In-Wheel Drive System**

- **20% extra capacity**
- Can be configured as **extra cargo space**
- Alternative design study is ongoing

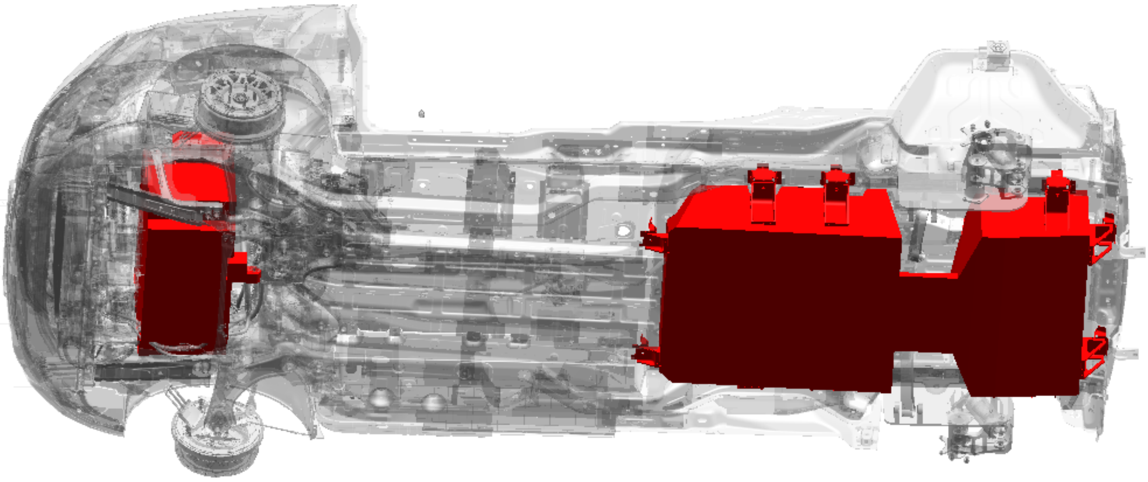


**Rear Pack: 71 kWh (Gross)**

**Impact of In-Wheel Suspension System**

- 3% critical extra volume
- Enabled to add 1 extra parallel string to reach 71kWh from 53 kWh
- **25% extra capacity** indirectly

One battery pack is located under the vehicle body while the other one is located under the engine hood as shown in the following figure:



## MODEL BASED REAL-TIME ROBUST HITCH ANGLE CONTROLLERS FOR CAR-TRAILER COMBINATIONS

Recent literature has shown that the inclusion of the **hitch angle measurement** for feedback control of the trailer oscillations in car-trailer combinations can bring significant safety benefits, with respect to conventional trailer oscillation mitigation algorithms based on the yaw rate of the towing car. Although previous studies have proposed a few preliminary examples of controllers using the hitch angle measurement for articulated vehicle stabilization, there is lack of performance comparisons of alternative direct yaw moment control formulations including trailer sway mitigation. Moreover, the available feedback hitch angle controllers are mostly based on linear control, or system linearization around its current operating condition.

To address the gap, four real-time implementable **nonlinear model predictive control (NMPC) algorithms** have been developed and tested in SYS2WHEEL. The first approach is a simple TV controller which uses the rigid vehicle as internal model. The reference yaw rate signal is based on specific formulation, which blends the contributions of the yaw rate and the hitch angle error, only when the trailer dynamics is deemed critical. The second algorithm uses the articulated vehicle as internal model. It considers a soft constraint on the hitch angle error that allows the activation of the hitch angle contribution only when predefined thresholds are exceeded. The third formulation, based on the articulated vehicle as internal model, includes the value of the hitch angle error in the cost function of the NMPC. The last algorithm is based on a weighted linear combination of yaw rate error and hitch angle error, where the latter has an influence only when pre-determined thresholds are exceeded. Similar to previous formulations, an articulated vehicle is used as the internal model.

The uniqueness of these algorithms developed by the University of Surrey consists of the **real-time implementation and a good performance** even in case different trailers are towed to the vehicle.