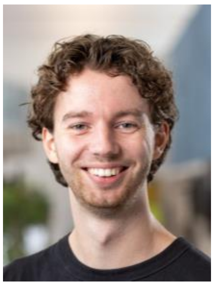
DEVELOPMENT OF INTEROPERABLE ELECTRICALLY DRIVEN SEMITRAILER CONTROLLED INDEPENDENTLY OF TRACTOR CAN DATA





K. KURAL
Associate Professor, HAN University of Applied Sciences, Netherlands.

B. HETJES
MSc, Researcher at HAN University of Applied Sciences, Netherlands

G. VAN STEKELENBURG
MSc, Researcher at HAN University of Applied Sciences, Netherlands

J.P. PAUWELUSSEN
Professor Emeritus at HAN University of Applied Sciences, founder & owner of PAVONODUM, Netherlands

M. VAN KLINK
Specialist trailer and body construction. Founder & owner of VAN KLINK ENGINEERING, Netherlands

Abstract

The upcoming EURO 7 regulation requires significant CO_2 reductions in road freight, targeting towing vehicles and semitrailers. Semitrailers face a 10% reduction goal, with limited gains from aerodynamic tweaks and low rolling resistance tires, making electrification the most promising solution. Electrified semitrailers hybridize diesel-powered setups, suiting both long- and short-haul routes. However, mass adoption is hindered by interoperability issues, as current designs depend on tractor-specific CAN-data, limiting compatibility across OEMs and models. This paper reports on the first results of CHANGE project which overcomes the challenge by creating an interoperable electrified semitrailer that bypasses CAN-data. Instead, CHANGE uses a load-sensing kingpin coupling, vehicle state estimation, and data from the semitrailer's Electronic Brake System (EBS). The objective is to ensure robust traction and energy recuperation through a predictive controller, balancing braking and traction to optimize energy use based on mission profiles.

Keywords: Electrification, Heavy Vehicles, Sustainable Freight Transport, Data

1. Introduction

The upcoming European EURO 7 regulation, which aims to reduce air pollution from vehicles, also includes significant reductions in carbon dioxide (CO_2) emissions from road freight transport. In addition to towing vehicles, which must cut their emissions by 45% by 2030, the regulation introduces new requirements for trailing units, such as semitrailers, which will also need to actively contribute to CO_2 savings. The European Commission has set ambitious targets, requiring trailing units to achieve a 10% reduction in CO_2 emissions. Several enablers have been identified to help reduce the carbon footprint of semitrailers, including aerodynamic enhancements such as boat tails or side skirts, reduced rolling resistance through advanced tire technology, and lightweight vehicle body construction. However, preliminary estimates from semitrailer OEMs suggest that the combined impact of these improvements would only achieve a maximum CO_2 reduction of 7-8%, considering both short- and long-haul transport. If these requirements are not met, trailer OEMs could face fines of approximately €15,000 per semitrailer produced. Consequently, semitrailers commissioned from 2026 onwards in Europe will need to incorporate significant innovations to comply with the new regulation. One of the most impactful solutions to meet these targets appears to be the electrification of semitrailers. Since July 2024, European legislation under REGULATION (EU) 2018/858 on the approval and market surveillance of motor vehicles and their trailers has formally recognized the term "e-trailer." It defines an e-trailer as a trailer capable of contributing to the propulsion of the vehicle combination via its own electric powertrain, but one that cannot operate on public roads independently without being actively towed. However, as of now, no directive currently allows the operation of such vehicles on public roads.

An e-trailer enables the hybridization of traditional vehicle combinations with a diesel-powered tractor and can be deployed for both long- and short-haul transport. Electrification of the semitrailer can be achieved through modifications to existing vehicles, requiring only investment in retrofitting rather than purchasing entirely new units. Energy can be harvested during braking through kinetic energy conversion, which not only contributes to power generation but also extends the lifespan of brake pads by reducing mechanical wear. The stored energy can then be utilized during acceleration or on inclines, improving both gradeability and acceleration of the vehicle combination on traffic lights or railway crossings. Additionally, the recovered energy can power secondary electric auxiliaries, such as refrigerated (reefer) cooling units. This means that a portion of the power required to tow the semitrailer—normally supplied by the diesel engine—would instead come from a zero-emission electric powertrain, effectively reducing the carbon footprint of the entire vehicle combination. This may also lead to downsizing the towing vehicle's powertrain (both diesel and electric), potentially reducing the overall weight of the towing unit, as documented by Aish et al. (2023).

Moreover, an e-trailer serves as a crucial transition toward zero-emission mobility, allowing for a gradual phase-out of fossil-fuel-powered tractors until electric tractor units become more affordable. Currently, the cost of an electric tractor unit is more than three times that of a conventional diesel tractor. Besides cost, another significant obstacle to the widespread adoption of fully electric tractors is the lack of charging infrastructure along Europe's main logistics corridors (TEN-T), which is far behind schedule. According to ACEA (2024), by 2030, 1,700 Megawatt Charging Systems (MCS) will be required, whereas currently, none exist. In Europe, two major initiatives are currently underway to develop and prototype e-trailers, as shown in Figure 1. However, neither initiative aims to offer retrofittable solutions for existing semitrailers, meaning that potential users must purchase an e-trailer directly from OEMs collaborating with specific electric powertrain developers.

a) **b)**

Figure 1 – Prototypes of E-tailers: a) ZF-WABCO (2024), b) Trailer Dynamics (2024).

Despite the advantages of deploying e-trailers, several bottlenecks exist. The most significant challenge is interoperability. Currently, most e-trailer prototypes rely heavily on CAN-data from the tractor, which must be shared with the e-axle controller. As a result, switching between tractor units from different OEMs or production years undermines interoperability—a crucial factor for deployment, as permanent connections between tractors and semitrailers are rare. This issue is widely recognized in the logistics industry, where tractors and semitrailers are frequently interchanged to maximize operational efficiency and fleet utilization.

Another concern regarding electrified semitrailers arises from a usability perspective. Key components, such as tires, will wear differently than on conventional semitrailers. Likewise, electric powertrain components, particularly batteries, will degrade based on usage and charging patterns. Therefore, monitoring wear and degradation trends is crucial as identified also in ZEFES (2025). A predictive maintenance approach must be adopted to prevent failures and minimize downtime. In response to these challenges, a four-year research project, CHANGE, has been established, bringing together research institutes, semitrailer OEMs, and Dutch freight transport organizations. The project has two main objectives:

- Develop an interoperable electrified semitrailer that does not require CAN-data from the tractor.
- Create predictive maintenance models for critical components using data science techniques.

The research approach of the CHANGE project is depicted in Figure 2. As shown, it relies on three key pillars: AI/Machine Learning, Digital Shadowing, and Experiments. Each of these approaches utilizes readily accessible input data, such as vehicle dimensions, road profiles, and driver inputs, to ultimately achieve two main objectives—controlling the e-trailer and monitoring the condition of critical components for predictive maintenance. Given that the project is still in its early phases, this paper primarily reports on the initial results related to data analysis required for development of the e-trailer control algorithm, and market review to identify components subjected to the predictive maintenance along with sizing of electric powertrain.

The paper is structured as follows, first, the key components for predictive maintenance are identified, along with the sizing of the electric powertrain, based on use cases derived from an extensive market review and discussions with key stakeholders in the transport sector. Secondly, the data analysis is presented to assess which data signals are available in the semitrailer EBS system and how they can be leveraged for controller development. Next, an overview of the development of the digital shadow for the e-trailer is provided, along with initial results. Finally, the paper concludes with a research outlook and directions for future work.

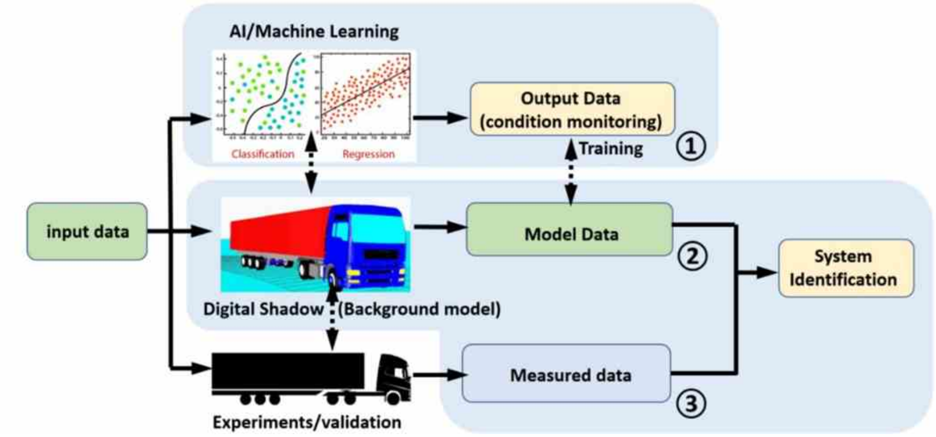


Figure 2 – General functional scheme of CHANGE.

2. Market Needs Research

The project was initiated with several scrum sessions and interviews conducted with trailer OEMs, first-tier suppliers, end users, service centers, branch organizations, and knowledge institutions. A number of key topics were discussed with stakeholders, including the identification of semitrailer components that should be subjected to Predictive Maintenance (PM) or sizing of the electrical powertrain.

2.1 Define the semitrailer components to be subjected to Predictive Maintenance

The primary objective of Predictive Maintenance (PM) is to minimize semitrailer downtime caused by component failures, which can negatively impact productivity and efficiency. Unexpected breakdowns, particularly on the road, are not only undesirable but can also disrupt traffic, potentially causing congestion or even dangerous situations. While general maintenance is unavoidable, controlling when it occurs is crucial for maximizing operational efficiency. PM enables this by analyzing semitrailer usage data against predefined failure criteria to estimate potential wear levels and determine the remaining useful life (RUL) of critical components. To successfully implement PM, it is essential to identify the primary causes of trailer failures and the systems most prone to operational wear and tear. Determining the focus areas of PM, and whether they differ across OEMs and trailer manufacturers, is a crucial step. Discussions with industry experts and trailer OEMs revealed a consensus that tires should be prioritized due to their high value and significant impact on operations. Secondly, the brakes and braking system were also identified as key components for PM implementation.

Beyond tires and brakes, the primary causes of trailer failure and the components most susceptible to wear can vary slightly among manufacturers. For instance, air bellows may be a common failure point for some trailers, while other components are more critical for specific manufacturers:

- Trailer Manufacturer A identified the batteries that power the loading floor and tailgate as particularly sensitive.
- Trailer Manufacturer B highlighted the moving floor, specifically its thickness and the oil pump (pressure), as key concerns.
- Trailer Manufacturer C prioritized the hydraulic pump for ramps or steered axles as a primary risk factor.

Due to these manufacturer-specific variations, the initial focus of PM was placed on tires and brakes. Once these systems are effectively addressed, the methodologies and frameworks developed in the project may also be applied to other critical subsystems. Both tires and brakes were further classified into two categories based on industry and OEM input:

- Unexpected Failure: Refers to critical incidents, such as tire blowouts or brake fires, that lead to immediate downtime and must be proactively prevented.
- Regular Wear: Covers gradual degradation, such as reducing tire tread depth or thinning brake pads. By monitoring these patterns, maintenance and replacements can be better planned, reducing the risk of unexpected failures.

These two failure categories require different types of data signals, which are summarized in Table 1. The table outlines the causes of unexpected failures and regular wear, along with the data that should be monitored to support predictive maintenance. This dual approach ensures both immediate risk mitigation and long-term efficiency in trailer maintenance planning.

Table 1 - Overview of the main causes of trailer failure and wear-sensitive systems.

No.	Name	Type of Failure	Reason / Consequence	Measured by
F.1	Tyre blowout	Unexpected failure	Incorrect tyre pressure	Tyre pressure [Pa] exceeding a (upper or lower) threshold value
F.2	Tyre blowout	Unexpected failure	Excessive temperature due to incorrect tyre pressure (see F.1) or burning brakes (see F.3)	1) Tyre pressure [Pa] exceeding a (upper or lower) threshold value 2) Tyre temperature [^{o} C] exceeding a (upper) threshold value
F.3	Burning brakes	Unexpected failure	Result of (partly) seized brakes due to a leakage in the (parking) brake system (e.g. broken spring-brake-cylinder)	1) Brake temperature [^{o} C] exceeding a (upper) threshold value. 2) Air brake (system) pressure [Pa] drop and/or exceeding a (lower) threshold value. 3) Brake forces [N] discrepancy between wheels.

W.1	Worn tyre	Regular wear	Normal wear / tear from use. (the wear differs per axle / tyre location)	Consumed / left over tread depth [mm] calculated or estimated by the (individual) tyre forces [N]
W.2	Worn brakes	Regular wear	Normal wear / tear from use. Wear on discs / pads, drum/shoe, etc.	Consumed / left over thickness of brake system components [mm], calculated by the (individual) brake forces [N] or brake energy [kW]

Given that the main goal of the project is to develop an electrically driven semitrailer that operates independently of tractor CAN data, a third critical component identified through stakeholder interviews is the battery pack. Unlike brakes and tires, the battery pack's degradation is influenced by control algorithms and trip strategies, making its PM blueprint qualitatively different. This selection is also logical, as key signals such as state of charge (SoC) and internal battery temperature will be readily available and accessible for monitoring. By leveraging this data, a targeted PM approach can be developed to optimize battery lifespan and performance.

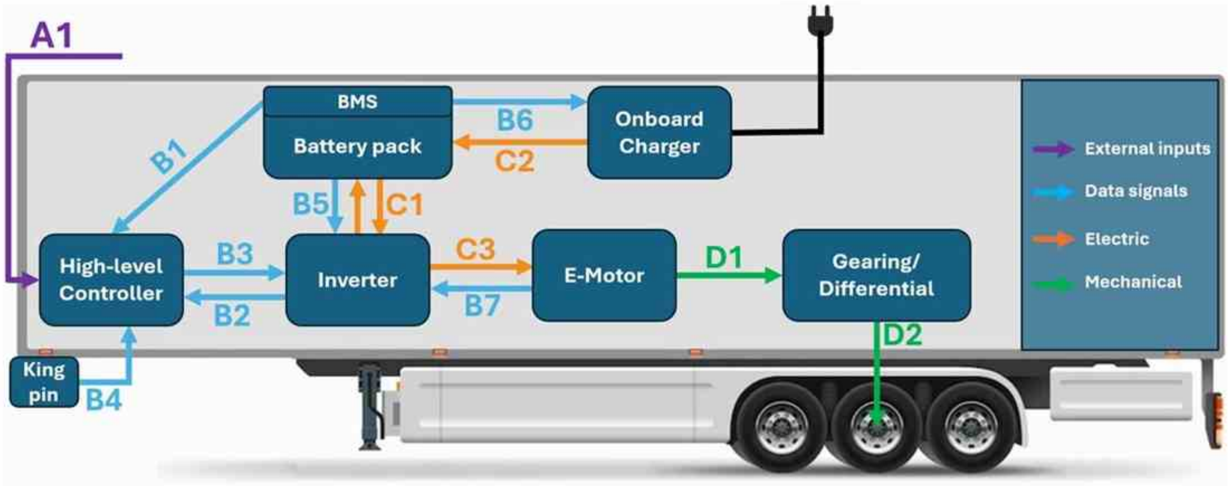
2.2 Sizing of the Electrical powertrain

The ambition of CHANGE is to electrify two different types of semitrailers. As shown in Figure 3a), the first type is a double-deck semitrailer with independent wheel suspension. In Figure 3b), the second type is a tri-axle semitrailer with rigid axles and a walking floor.

a) b)

Figure 3 – e-trailer types: a) independent wheel suspension b) rigid axles.

To define the sizing of the electrical drivetrain, the functional architecture and components of the e-trailer are first discussed. As shown in Figure 4, the e-driveline consists of six main components: a Battery Pack, a Charger, a Battery Management System (BMS), an Inverter, an Electromotor, and a Controller. The battery pack stores energy and provides the necessary DC-based electrical power to different components. It can be recharged using the charger. The BMS monitors the operational state of the battery pack and its individual cells, protecting them from operating outside safe parameters (e.g., temperature, voltage, or state of charge). It also manages charging and discharging, including cell balancing. The inverter converts DC power from the battery into AC power, which feeds the electromotor. It can also work in reverse, converting AC power generated from kinetic energy recuperation (during braking) into DC power, which is then stored in the battery pack, with the flow controlled by the BMS. The inverter also acts as a low-level controller, regulating the amount of electric power supplied to the electromotor based on the drive/brake torque demand from the high-level controller developed in the CHANGE project introduced by Pauwelussen, (2025). As shown in Figure 4, the high-level controller takes multiple inputs, including data from the BMS (B1), current operating points of the inverter (B2), and information from the force-sensing kingpin (B4), which is extensively explained by Hetjes (2025). The final input comes from the trailer EBS system (A1), which will be discussed later. Based on these inputs, the high-level controller determines the torque request, which is executed by the electromotor using power from the inverter. The final part of the powertrain is the differential/gearing transmission, which converts the electromotor torque into drive axle torque.



	A1	Additional Controller inputs (t.b.s.)
	B1	SOC [%], Battery Temperature [°C], Battery Current [A], Battery Voltage [V]
	B2	Inverter Voltage [V], Inverter Current [A], Inverter Temperature [°C], E-motor Voltage [V], E-motor Current [A], E-motor Temperature [°C], E-motor Velocity [rpm], E-motor Torque [Nm]
	B3	Torque Request [Nm]
	B4	Kingpin longitudinal forces [N]
	B5	Max. charge current [A], Max. discharge current [A]
	B6	BMS data
	B7	E-motor Velocity [rpm], E-motor Voltage [V], E-motor Current [A], E-motor Temperature [°C], E-motor Torque [Nm]
	C1	Battery Voltage [V], Battery Current [A]
	C2	Charger Voltage [V], Charger Current [A]
	C3	E-motor Voltage [V], E-motor Current [A]
	D1	E-motor Torque [Nm]
	D2	Drive axle Torque [Nm]

Figure 4 – Functional architecture of the electric driveline of an e-trailer.

The sizing of the main components—the battery pack, the electric motor, and the inverter—has primarily been determined based on the operational conditions and the expected deployment of the semitrailer for short-haul transport. Given that two different layouts of e-trailers are being produced, two different types of electric motors are listed in Table 2. This is because the e-trailer (Figure 3a) is equipped with two electric motors due to its independent wheel suspension, which allows for an increase in the cargo space's transport volume, whereas e-trailer (Figure 3b) is of more conventional layout and hence requires only one electromotor.

Table 2 – Overview of main electrical component specifications.

Component / Parameter name	Unit	Burgers Trailer	Kraker Trailer
Battery Pack		**OTTOMOTIV**	
Energy	[kWh]	78.9	
Nominal Capacity	[Ah]	117	
Nominal Voltage	[V]	675	
Operating Voltage (dc)	[V]	540 - 756	
Charging operating temp.	[ºC]	0 - 50	
Discharging operating temp.	[ºC]	-10 - 50	
Max Rated Current ((dis)charge)	[A] (C)	117 (1)	
Max Pulse Current ((dis)charge)	[A] (C)	350 (3)	
Inverter		**DTI HV850 (2x)**	**DTI HV850 (1x)**
Input Voltage range (dc)	[V]	30 - 800	
Input Current maximum (dc)	[A]	400	
Operating Voltage (dc)	[V]	200 - 800	
Maximum AC (peak) current	[A]	850	
Maximum output Power	[kW]	320	
Switching frequency	[kHz]	8 - 14	
Maximum power dissipation	[W]	5600	
Operating Temperature	[ºC]	-20 – 85	
Regenerative braking mode	[-]	Yes	
Electromotor		**AXM3 (2x)**	**AXM4 (1x)**
Peak Power	[kW]	220	430
Continuous Power	[kW]	130	230
Peak Torque	[Nm]	525	950
Continuous Torque	[Nm]	310	600
Maximum motor speed	[rpm]	580	4500
Continuous motor speed	[rpm]	4000	3600
Operating Voltage	[V]	800	850
Kv (unloaded / loaded / peak)	[rpm/V]	12 / 9.5 / 8.4	6.3 / 4.9 / 4.3

3. Data Availability

Given that the goal of CHANGE is to develop a controller for the electromotor of the e-trailer that will be independent of the tractor data, an inventory of data availability on the trailer side is required to define the operational space for the upcoming research. To clarify the distinction between different data availability levels, color coding is used as shown in Figure 5. Each color reflects a different approach to obtaining data, balancing cost, feasibility, and reliability.

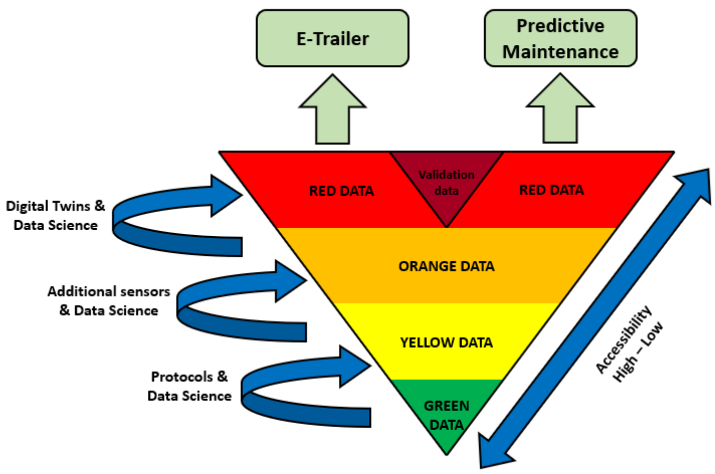


Figure 5 – Colour coding, describing the origin/source of the required data signals.

The "green data" cluster consists of signals that are always available and accessible on every trailer in the same way. These signals are standardized and come from two sources: the EBS system/CAN-bus, as defined by ISO 11992 (2024), and the Tyre Pressure Monitoring System (TPMS) in accordance with UN ECE-R 141 (2024). Some signals are also available through electrical connectors, either the 7-pin (ISO 1185 & 3731) or the 15-pin (ISO 12098) connector. The data in this cluster is limited both in number and content, and it can be directly used for electromotor control. An example of a 'green data' signal is shown in Table 3.

The "yellow data" cluster refers to data that is potentially accessible from the trailer but only available under certain conditions based on the configuration of the EBS system. More specifically, the available data content depends on the agreements made between the EBS provider and the semitrailer OEM. In general, the EBS system/CAN-bus (ISO 11992) can provide many more data signals than those included in the 'green data' cluster. However, additional data signals from the EBS depend on the configuration installed on the trailer, which is determined by the OEM. If certain systems or options are acquired and installed on the EBS, relevant signals will also become available on the CAN-bus (ISO 11992), and the same applies to TPMS. Additionally, telematics can be installed on the trailer EBS, enabling the reading of additional signals if there is a handshake between the EBS and the telematics system. This is typically the case when both systems are from the same manufacturer. Expanding EBS functionalities or installing telematics can be costly, and advanced configurations may double the price of the minimum required system. Therefore, OEMs must make careful choices. Examples of signals in the yellow cluster are provided in Table 3.

The "orange data," as shown in Table 3, refers to signals identified as relevant for controlling the e-axle electromotor but unavailable in the already installed and mandatory hardware (EBS, TPMS). These signals come from additional external sensors (such as a dedicated sensor or a sensor cluster in telematics) that will not impair the normal operation of the trailer. The cost of these sensors is low compared to electrical components. While the impact on the price is minor, it should be noted that using additional sensors is generally undesirable for trailer manufacturers, as it increases the cost of the trailer. Therefore, if it is possible to eliminate the need for additional sensors by making the data signal accessible through other means (e.g., using data science or mathematical techniques), this is considered the preferred option.

Table 3 – Examples of the data types.

Green data	Yellow data	Orange data	Red data
Vehicle ABS status	Axle load	Kingpin longitudinal forces	Tyre Forces
Vehicle retarder control status	Braking system wheel-based vehicle speed	Articulation angle	Truck engine torque
Vehicle dynamic control status	Tyre pressure	Ambient temperature	Trip parameters
Service brake demand pressure	Lateral acceleration	Geographic Position	Truck Engine Map
Brake light switch	Brake cylinder pressures	Time	Road gradient
Reverse light trailer	Wheel speeds	Semitrailer IMU data	Tractor IMU data

The "red data" refers to information that is neither accessible nor available in any of the previously described forms. As such, it cannot be extracted from existing trailer systems, regardless of the conditions (green and yellow), and it cannot be measured by additional, affordable sensors without disrupting the normal operation of the trailer (as with orange data). For example, measuring tire forces is possible with specialized equipment, such as Kistler (2025), but these sensors cannot be used during normal trailer operations, as they require calibration and are not designed for heavy-duty daily use. Furthermore, the costs of such sensors are significantly higher than those of the additional sensors described in the orange data. To make the red data signals accessible, various approaches can be explored, including data-driven solutions like state estimation, digital twinning, and system identification, which will be further discussed. To ensure the validity of the signals, a subset of red data was chosen to be intentionally measured on the tractor side (such as engine torque, IMU signals, or acceleration/brake pedals), which will be used for training and validation purposes. The red data is listed in Table 3.

In summary, it is clear that with reduced accessibility – especially for orange and red data – alternative approaches are needed to provide the data essential for both e-powertrain control and predictive maintenance. These efforts, represented by the blue arrows in Figure 5, infer inaccessible data using mathematical and data science techniques in combination with available data (e.g., green or yellow). The foundation of these techniques typically involves an accurate dynamic model of the vehicle combination, which can be simulated alongside real-life operations using measurement data (such as steering angle or pedal positions) as input. In turn, the model delivers unmeasurable states, such as tire forces. This technique is commonly referred to as digital shadowing and will be briefly described hereafter.

4. Digital Shadow Development

Digital shadows in context of CHANGE are adaptable mathematical models of tractor-semitrailer combinations. They can be customized in terms of dimensions, loading state, axle type, or powertrain layout, depending on the needs of CHANGE. This allows for modifications to accommodate various semitrailer types (see Figure 3) as well as different driveline configurations.

The models are developed in MATLAB/Simulink using the Simscape toolbox, a generic tool for modeling and simulating physical systems. Simscape allows users to simulate systems involving mechanical, electrical, hydraulic, and thermal components in an integrated environment. For complex, multi-domain systems like e-trailers, Simscape simplifies development by providing pre-defined, validated component blocks, eliminating the need for complex mathematical equations.

The e-trailers are integrated into a base model built with Simscape Multibody, which is designed for modeling mechanical systems with rigid bodies, joints, constraints, and motion elements. This model is based on the multibody tractor-semitrailer model developed by HAN Automotive Research and Eindhoven University of Technology, as described by Kural (2013). Over time, the model has been parameterized and validated to accurately represent a rigid tractor-semitrailer combination, including realistic non-linear tire behavior. It supports vehicle dynamics analysis and digital twinning applications. Figure 6 illustrates the tractor-semitrailer multibody model. For the full architecture of the model, we refer to Ajaykumar (2022).

Initially, the multibody model did not include any physical driveline systems in either the trailer or the tractor. The tractor was powered solely by torque applied to the rear wheels. To model the e-trailer, an electric driveline was added to the semitrailer. As mentioned, Simscape supports multiple physical domains, and therefore, electrical components, provided as pre-defined blocks within Simscape, were incorporated into the semitrailer, transforming it into an e-trailer.

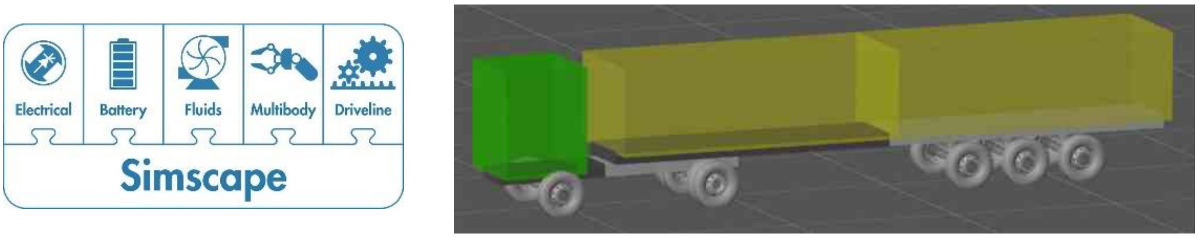


Figure 6 – Tractor Semitrialer multibody model built in Matlab Simscape.

Additionally, to enable fuel consumption analysis for the tractor, the model was further enhanced with an internal combustion engine (ICE) fuel consumption model and a transmission model. This will allow for high-fidelity testing and benchmarking of controllers developed by Pauwelussen (2025) prior to deployment in real-life testing. Furthermore, it is anticipated that a 'lightweight' version of the model may be used to assist in filtering the signals measured by the force-sensing kingpin developed by Hetjes et al. (2025).

5. Conclusion and Research Outlook

In this paper, we present the approach that the CHANGE project will take to develop an interoperable electric semitrailer that does not rely on the availability of tractor FMS data through the CAN-bus. We have outlined the accessibility of various data signal clusters, as well as the functional architecture of the intended electric driveline. Based on discussions with a group of stakeholders from various segments of the road freight transport domain, we have established a component sizing framework and identified a set of components that should be prioritized for predictive maintenance.

In the upcoming period, large amounts of data will be collected through a field measurement campaign using data acquisition hardware, which will be mounted on six conventional tractor-semitrailer combinations (i.e., not electrified) from three different semitrailer OEMs. Data will be intentionally collected not only from the semitrailer but also from the tractor, and it will be transmitted via 4G over-the-air to servers where the collection and processing will take place. This data will be used for predictive maintenance, to validate the digital shadow of vehicle combinations, and to test and iterate the controller for the electric axle across various missions.

In the next phase of testing, two prototypes of electrified semitrailers will be deployed in daily operations, equipped with the developed controllers and force-sensing kingpins. Since the high-level controller on the e-trailers will be permanently connected to the servers, it will be possible to test different versions of controllers and algorithms in real-time, optimizing energy savings.

6. References

- European Union. (2024, November 11). REGULATION (EU) 2018/858 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL.https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02018R0858-20240701
- UNECE, (2024, November 11), NORM ISO 11992, https://unece.org/DAM/trans/doc/2007/wp29grrf/ECE-TRANS-WP29-GRRF-62-inf09a1e.pdf
- UNECE, (2024, November 11), REGULATION UN ECE-R 141. https://unece.org/fileadmin/DAM/trans/main/wp29/wp29regs/2017/R141e.pdf
- ACEA, (2024, November 11), Electric cars: EU needs 8 times more charging points per year by 2030 to meet CO2 targets. https://www.acea.auto/press-release/electric-cars-eu-needs-8-times-more-charging-points-per-year-by-2030-to-meet-co2-targets/
- Google. (2024, November 11). Electrified Trailer ZF, https://images.app.goo.gl/EeSCYjXbAPQuB5dt7
- Google. (2024, November 11). Electrified Trailer Dynamics. https://images.app.goo.gl/XjhZqfWJ7t4UGmpz5
- Pauwelussen J.P., Van Klink, M., Hetjes, B. (2025), A Tractor Independent Power Based Control for Semi-Trailer Electric Propulsion, 18th HVTT symposium, Quebec, Canada
- Hetjes, B., Pauwelussen J.P., Van Klink, M., Kural, K., Khodabandeh, M. (2025), Force-Sensing Kingpin” for intelligent tractor-independent control of semitrailer E-axles, 18th HVTT symposium, Quebec (2025)
- Kural, K., Prati, A., Besselink, I.J.M., Pauwelussen, J.P. & Nijmeijer, H. (2013), Validation of longer and heavier vehicle combination simulation models, SAE International Journal of Commercial Vehicles, 6(2), pp. 340-352.
- Ajaykumar, S. (2022), Digital Twin Approach For Articulated Vehicle Performance Analysis, Master Thesis, HAN University of Applied Sciences.
- Kistler, (2025, February 18), https://www.kistler.com/INT/en/cp/wheel-force-transducers-for-trucks-and-commercial-vehicles-roadyn-s6-for-trucks/P0001269
- Aish, J.A., Pauwelussen, J.P., Kural, K., van Klink, M., Koppejan, R., van Meele, K. (2023): E-Ttrailer, emission reduction based on electrically propelled trailer, 17th HVTT Symposium, Brisbane.
- ZEFES (2025), Zero Emissions flexible vehicle platforms with modular powertrains serving the long-haul Freight Eco System, EU Horizon project, https://zefes.eu/